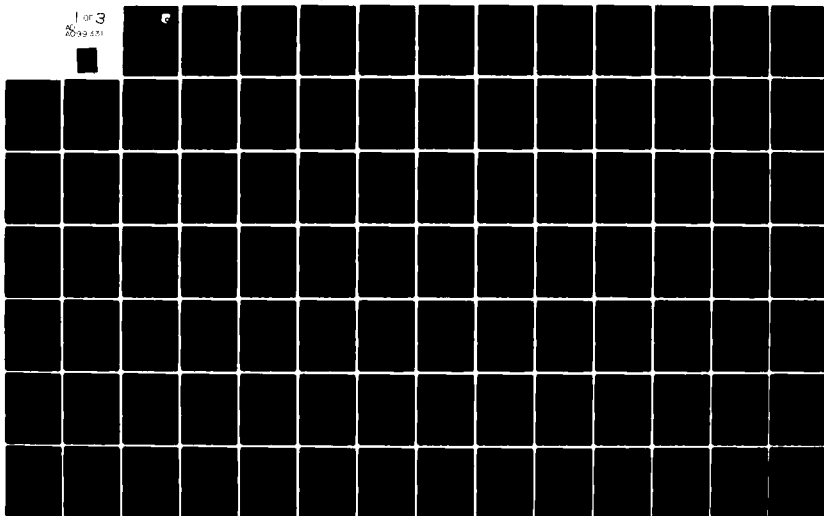


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AFWAL-TR-80-3032
VOLUME III

PREDICTION OF SUPERSONIC STORE SEPARATION
CHARACTERISTICS INCLUDING FUSELAGE AND
STORES OF NONCIRCULAR CROSS SECTION.
VOLUME III - APPENDICES A AND B, DETAILS
OF PROGRAM I

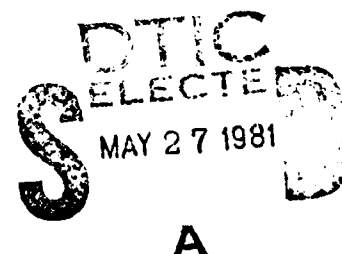
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November 1980

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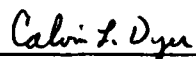
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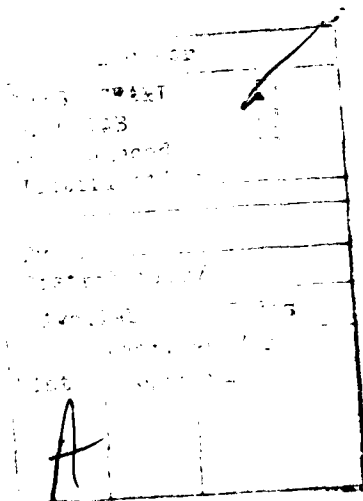
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to model circular fuselages and stores. The noncircular fuselage and elliptic store surfaces are modeled with constant source panels. Nonlinear corrections are made to the wing, fuselage, rack, store and fuselage inlet models to simulate shocks. The program also calculates the trajectory of the store as it separates from the aircraft. This report describes the program, presents instructions for preparing input for the program, describes the output from the program, and presents a sample case. The program represents an extension of an earlier program restricted to circular bodies at supersonic speeds, written by the present authors and described in AFFDL-TR-76-41.

→ This volume presents the detailed descriptions of the calculations performed in each of the subroutines in Program I. Also included are the descriptions of each of the variables passed between routines.



FOREWORD

This report entitled "Prediction of Supersonic Store Separation Characteristics Including Fuselage and Stores of Noncircular Cross Section," describes a combined theoretical-experimental program directed toward developing a computer program for predicting the trajectory of an external store separated from an aircraft flying at supersonic speed. It represents an extension of previous work covered in AFFDL-TR-76-41 to include more realistic modeling of fuselage shapes including noncircular cross sections and ramp type engine air inlets, and to include modeling store shapes with elliptic cross section with multiple sets of arbitrarily oriented fins. Volume I, "Theoretical Methods and Comparisons with Experiment", describes the theoretical approach and presents extensive comparisons with experimental data. Volume II, "Users Manual for the Computer Program", presents detailed instructions on the use of the computer program with emphasis on preparation of input data and interpretation of output. This volume, Volume III, "Appendices A and B, Details of Program I", provides additional descriptions of the individual subroutines and program variables passed between modules in the first of two programs. Volume IV, "Appendices C and D, Details of Program II", provides additional descriptions of the individual subroutines and program variables passed between modules in the second program.

This work was carried out by Nielsen Engineering & Research, Inc. (NEAR), 510 Clyde Avenue, Mountain View, California 94043, under Contract No. F33615-76-C-3077. The contract was initiated under Project 2403, Task 240305, of the Air Force Flight Dynamics Laboratory. The Air Force Project Engineer on the contract was Calvin L. Dyer, AFWAL/FIGC. The report number assigned by Nielsen Engineering & Research, Inc. is NEAR TR 210.

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PREDICTION OF SUPERSONIC STORE SEPARATION
CHARACTERISTICS INCLUDING FUSELAGE AND
STORES OF NONCIRCULAR CROSS SECTION

Volume III - Appendices A and B, Details of Program I

SUMMARY

The purpose of this volume is to provide the additional details of the parts of the first program that would be useful to the programmer or engineer interested in understanding the calculations and computer code herein. The information included here as Appendices A and B describes the function and operations performed by each routine, a description of data transferred between subroutines and a listing of Program I itself.

Appendix A provides a detailed description of the operations and flow of calculations of each of the individual routines in Program I. Included are a description of the flow of the calculations, including flow charts of some routines, a description of any program arguments, and a program listing.

Appendix B provides a description of all variables passed between routines in common blocks. A listing of each common block with a description of each variable, array, or index in the common is provided. A special section is provided for the multiple uses of blank common as well as a cross reference chart of routine versus common block usage.

APPENDIX A
DETAILS OF PROGRAM I SUBROUTINES

A-1 Introduction

The purpose of this appendix is to provide more detailed information on the calculations performed in the first program which was described in Section 3 of Volume II. A listing of Program I is presented in Figure A-1 and a general flow chart in Figure A-2. This appendix will present the details of the flow of the calculations for each routine, a description of the variables in the argument list, individual detailed flow charts, and a summary of the functions of each routine. The program consists of a main program and 59 subroutines. The main program will be described and then the subroutines will be described in alphabetical order. The subroutines and their functions are listed in Table A-1. Flow charts of some of the individual routines are shown in Figures A-3 through A-18. Refer to Volume II of this report for the list of symbols used in this text.

TABLE A-1. SUBROUTINES USED IN PROGRAM I

<u>Subroutine</u> <u>Name</u>	<u>Function</u>
LDCALC	main program to organize calculation flow
ASECTN	calculates cross sectional area of an arbitrarily paneled body
BDYGEN	calculates line sources and doublets to give a required body shape and angle of attack
BLYOUT	lays out fuselage constant u-velocity panels for circular body
BLYOT2	lays out noncircular fuselage constant u-velocity panels

BODPAN	organizes the calculation of the revised axial spacing for the noncircular fuselage source panels
BODPN2	performs the revision of the axial spacing on the noncircular bodies and computes the body panel geometry
BODVEL	organizes the looping through source panels to compute panel influence coefficients
BSHOCK	computes the nonlinear shock wave shape emanating from the nose of a noncircular body
CONFIG	reads and prints the input geometrical description of the external shape of noncircular fuselage or elliptic stores
DOUBLT	calculates the strength of a linear line doublet
DPCOEF	calculates coefficient matrix of the set of equations to be solved for the wing-pylon-fuselage constant u-velocity panel strengths
DPRHS	calculates right-hand side of the set of equations to be solved for the wing-pylon-fuselage constant u-velocity panel strengths
FLDVEL	organizes the calculation of the u,v,w velocity components at the field points XFP,YFP,ZFP
FLDVL2	computes the three components of velocity induced at field points by the source panels of a given body ring
FRSTRT	saves or restores required program information for source panel model to restart configuration analysis
FUSEIO	reads and prints fuselage data and calls BDYGEN to calculate line source and doublet distributions and SHKSHP to compute nonlinear shock for circular bodies
GEOM	organizes the reading and printing of the noncircular body input and the calculation of the source panel geometry arrays

INLSHK	computes the nonlinear shock shape emanating from a ramp type inlet
INLTST	determines whether a source panel is an inlet panel
INLXYZ	scans the x,y,z coordinates of the inlet panel corners to determine inlet geometric parameters
INVER1	solves a system of simultaneous linear algebraic equations
IOREAD	performs an unformatted read from external file, IO
IOWRIT	performs an unformatted write onto the external file, IO
NETCLC	calculates the net corner strengths for a given set of wing, pylon, or fuselage constant u-velocity panels
NEWRAD	organizes the revision of the noncircular body meridian line spacing for the source panels
NEWRD2	computes the revised noncircular body meridional line spacing for a given body segment
NULYT	selects a subset of constant u-velocity and wing and pylon thickness panel layout data and calculates and saves the net strengths associated with each panel corner
PANEL	calculates the direction cosines of the normal vector, the centroid, area and inclination angles of an arbitrary quadrilateral panel
PANVEL	transforms field points into local panel coordinates and calls SORPAN for the calculation of the panel influence coefficient
PAS001	performs the L*U decomposition of a positive definite matrix
PAS002	solves the system of equations $[L*U]*X = B$
PLYOUT	reads and prints pylon data and lays out constant u-velocity panels on the pylon

PYTHIN	reads pylon thickness data
RACKIO	reads and prints the rack data and calculates the rack source and doublet distributions
SHAPE	calculates the radius and surface slope at a point on a body from input polynomials
SHKSHP	calculates the nonlinear shape of the shock wave shape produced by an axisymmetric body at zero angle of attack
SMARCH	solves for the source panel strengths in supersonic flow using a ring by ring marching technique
SOLVE	computes the source panel boundary condition for a noncircular body in the presence of a free stream angle of attack and calls SMARCH to compute the panel strengths
SORPAN	computes the three velocity components induced at a specified control point by a constant source panel inclined to the free stream
SOURCE	calculates the strength of a linear line source
STORIO	reads and prints store data and computes circular body line source and doublet distributions and shock shapes or elliptic store source panel strengths and shock shape
SWNGIN	reads and prints wing constant u-velocity panel data and twist and camber data, if any
THKLYT	lays out wing and pylon thickness panels
THKOUT	prints wing and pylon thickness panel input data
VELBD1	calculates influence functions due to a fuselage constant u-velocity panel
VELCAL	calculates velocities at a field point due to fuselage or store line sources and doublets
VELCMP	organizes and calls for the calculation of the aerodynamic influence coefficient matrices for the body source panels

VELO1	calculates the influence of a semi-infinite triangle associated with a constant u-velocity panel
VELOT1	calculates the influence of a semi-infinite triangle associated with a thickness source panel
VELPP1	calculates influence functions due to a pylon constant u-velocity panel
VELPT1	calculates velocities at a field point due to pylon thickness source panels
VELWP1	calculates influence functions due to a wing constant u-velocity panel
VELWT1	calculates velocities at a field point due to wing thickness source panels
WDYBDY	reads and prints noncircular fuselage data and organizes the calls for the body source panel layout, source strengths and nonlinear shock shape
WITHIN	reads wing thickness data
WLYOUT	lays out constant u-velocity panels on wing
WRFILE	writes the dataset on TAPE12 which contains the information required to continue the supersonic store separation computations in Program II
YZBIP	organizes the scan of the source panel geometry to define the cross section of the noncircular fuselage interference shell
YZBIP2	interpolates in the panel geometry of a segment to define the y-z values of the noncircular interference shell

A-2 Program LDCALC

The flow chart which was presented in Figure 2 of Volume II details the basic flow of the calculations in program LDCALC and will not be expanded in this appendix. A written summary of the calculations to be made in the first program is presented. A listing of the program is presented in Figures A-1(a) and A-1(b) of this report.

LDCALC organizes the reading and printing of input and the calculation of the strengths of the singularities modeling the individual parent aircraft and store components. The constants, flow conditions, and component options are first defined. The source strength solutions are then defined for the circular fuselage in FUSEIO or for the noncircular fuselage in WDYBDY. The wing u-velocity panel data are read in SWNGIN and the panel layout is defined in WLYOUT. The wing thickness data are read in WITHIN. PLYOUT and PYTHIN perform similar functions for the pylon. The thickness distribution is printed from THKOUT and the thickness panel layout for wing and pylon occurs in THKLYT. The u-velocity panel layout for the circular fuselage is generated in BLYOUT and in BLYOT2 for the noncircular fuselage. A source strength model may also be generated for the rack in RACKIO. The source strength determination for either circular or elliptic store bodies are then computed in STORIO. The right hand side and influence coefficients for the u-velocity panels are computed in DPRHS and DPCOEF, respectively. The panel solutions are solved for from the set of simultaneous equations in INVER1. A summary of the panel control points and solutions is printed. The modified layout based on strengths summed at panel corners is then generated in NULYT. The necessary arrays and variables are lastly saved on TAPE12 in WRFILE for restarting the problem in the second program.

Subroutine references

BLYOUT, BLYOT2, DPCOEF, DPRHS, FUSEIO, NULYT, PLYOUT, PYTHIN, RACKIO, STORIO, SWNGIN, THKLYT, THKOUT, WDYBDY, WITHIN, WLYOUT, WRFILE.

A-3 Subroutine ASECTN

Subroutine ASECTN computes the cross sectional area of an arbitrarily paneled body. It is used to compute the area enclosed by arbitrary Y and Z values at each station in the external specification of the body shape. It is called from CONFIG. The equation used to define the area is

$$\text{AREA} = \sum_{i=2}^{\text{NRAD}} \frac{1}{2} (Y_i \cdot Z_{i-1} - Y_{i-1} \cdot Z_i) \quad (\text{A-1})$$

If the body is symmetric the sum is computed for the half body and doubled. A listing of the routine is presented in Figure A-1(b) of this report. A description of the parameters in the argument list follows:

Y,Z	arrays of section corner points
NRAD	number of points around section
AREA	area of cross section

Called by
CONFIG

A-4 Subroutine BDYGEN

Subroutine BDYGEN calculates the line source and doublet strengths using control points on the surface of the fuselage and store. The method used is described in Appendix I of Reference 1. A listing of the subroutine is presented in Figure A-1(c) and a flow chart in Figure A-3 of this report. The

coordinate system associated with the subroutine is shown in the sketches of Appendix I of Reference 1.

At the beginning of the subroutine a test is performed to determine if, at the base of the body, the radial distance to the Mach cone emanating from the body nose is less than the maximum radius of the body. If so, an error message is printed out (see Section 3.5 of Volume II) and the program stops.

Next, as the flow chart indicates, N is set equal to $NXBODY - 1$ and the body axis is divided into N segments of equal length. The x locations of the body definition points, $XBODY(J)$, are determined at these equally spaced axis points and, inside a short DO loop, subroutine SHAPE is called to calculate the radius of the body, $RBODY$, and the surface slope, $RPBODY$, at each body definition point. Subroutine SHAPE requires that the shape definition quantities be made dimensionless by body length. Subroutine BDYGEN accounts for this before and after the calls to subroutine SHAPE. Next, the control points are located effectively midway between the body definition points. Subroutine SHAPE calculates the body radius, RF , and the surface slope, $DRDX$, at each control point. Finally, the axis points, TX , which are the origins of the conical line sources and doublets, are determined.

The next sections of the subroutine are devoted to revising the layout of the body definition points and control points and the origins of the line singularities if the first control point lies outside the Mach cone originating at the body nose. An iteration is performed to determine the intersection of the cone with the body surface. Once this point is found the body definition points are redistributed over the remainder of the body. The procedure described in the previous paragraph is used

to redefine the control points and the origins of the line singularities.

The remainder of the subroutine calculates the source and doublet strengths at the control points. Subroutine SOURCE is called and the source strength at the first control point is calculated using Equation (I-14) and at the remaining control points using Equation (I-17) of Reference 1. One should note that the Ith source strength, $T(I)$, is the constant K_{I-1} in the algebraic notation of the equations. Similarly, using subroutine DOUBLT, the doublet strengths are calculated using Equation (I-27) for the first control point and Equation (I-28) of Reference 1 for the remaining control points. Here, the Ith doublet strength, $TC(I)$, equals $K_{d,I-1}$.

After calculating the source and doublet strengths, the subroutine prints the body definition point data, the singularity origins, and the singularity strengths and sums the source and doublet strengths. A description of the parameters in the argument list follow:

NXBODY	number of body definition points
RADIUS	maximum radius of body
BODYL	length of actual body
NSEG	number of polynomials used to specify body shape
XEND	array containing x locations of end points of polynomial sections specifying body shape, made dimensionless by body length
SCOEf	array containing coefficients of polynomials used to specify body shape

T array containing source strengths; T(J) is the
 quantity K_{J-1} calculated by Equations (I-14) and
 (I-17) of Reference 1

TC array containing doublet strengths; TC(J) is the
 quantity $K_{d,J-1}$ calculated by Equations (I-27) and
 (I-28) of Reference 1

TX array containing x locations of origins of conical
 line sources and doublets; positive, measured from tip
 of nose

ALPHA angle measured between the body centerline and the
 free-stream direction

RPBODY(I) slope of body surface at Ith body definition point

LBODY BODYL*XEND(NSEG)

SUMK sum of the source strengths

SUMKD sum of the doublet strengths

Subroutine references

DOUBLT, SHAPE, SOURCE

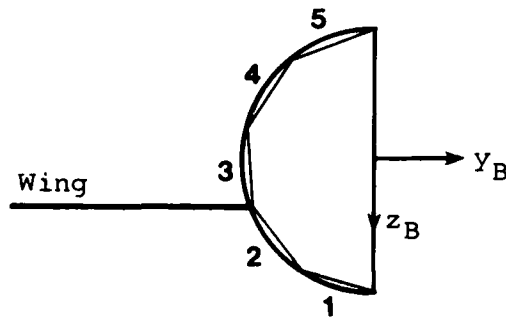
Called by

FUSEIO, RACKIO, STORIO

A-5 Subroutine BLYOUT

Subroutine BLYOUT calculates quantities needed to define the constant u-velocity panels on the circular fuselage and to locate the panel control points. The corner and control point coordinates calculated for the body panels are stored in arrays in locations which follow the same quantities calculated for the wing and pylon constant u-velocity panels. All coordinates are in the wing coordinate system which is shown in Figure 6 of Volume II. A listing of the subroutine is presented in Figure A-1(d) and a flow chart in Figure A-4.

The fuselage interference panels are laid out on the left-half of the fuselage surface, as shown in Figure 3 of Volume II. The panel numbering convention employed in a typical ring containing five panels, three above the wing and two below, is shown in the following sketch.

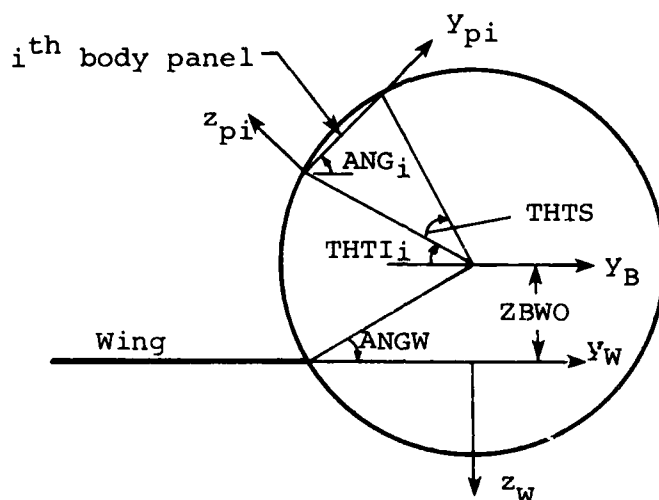


At the beginning of the subroutine, quantities DX , NBD , $NBIP$, and $ANGW$, associated with the geometry of the entire panel layout, are calculated. Next, the variable $ANGW$ is tested to determine if the wing is tangent to the fuselage, either at the top or at the bottom. As the flow chart shows, this tangency condition determines the initialization procedure performed before the main loop calculations.

The main part of the subroutine is a double DO loop with the outer loop index running over the rows above or below the wing and the inner loop index over the NCWB panels in a lengthwise

row. If the wing is not tangent, this double loop is performed first for the panels below the wing, then repeated for the panels above the wing.

For a given lengthwise row the y, z coordinates of the panel corners and the control points are first obtained in the panel coordinate system. The following sketch shows the coordinate system and certain quantities associated with a panel located above the wing.



Within the inner DO loop the coordinates are transformed into the wing coordinate system and stored in appropriate array locations. Polar angle $THTI$ and quantities $SNT2$ and $CST2$, necessary for panel-wing transformations, are saved in arrays for subsequent use by other routines. The corner and control point x_w coordinates are calculated and stored; no transformations are necessary for these quantities.

The convention employed in labeling the corner coordinates for the fuselage interference panels is that the right side of the panel is located in clockwise rotation from the left side, when looking forward.

Called by
LDCALC

A-6 Subroutine BLYOT2

Subroutine BLYOT2 computes the u-velocity panel corner points, control points, and transformation angles for the noncircular fuselage body shape. The section geometry is obtained from YZBIP at the user specified body x-station in the arbitrary fuselage geometry description. The section generated is held constant in cross section in the axial direction. No logic has been provided to force panel edges at the wing-body interface to match. The initial paneling of the body by the user must be performed so as to guarantee the matching of the panel edges with the wing root chord. A listing of the routine is presented in Figure A-1(e) of this report.

BLYOT2 performs two loops when generating the tables of panel properties. The outer DO loop steps through the number of panels around the circumference to generate the local section properties as shown in Figure 18 of Volume II. The inner DO loop increments the indices axially to repeat the identical section geometry for the remaining downstream panels on the body interference shell. The panel properties are laid out starting at the bottom for the left hand side. All quantities defined maintain the same definitions and conventions used in BLYOUT for the circular fuselage.

Called by
LDCALC

A-7 Subroutine BODPAN

Subroutine BODPAN organizes the calculation of the revised axial spacing for noncircular fuselage source panels. The starting locations in blank common of all arrays used to define the geometric properties of the panels are computed. The routine

loops on the number of body segments used to specify the body shape. Subroutine BODPN2 is called for each of NFUS segments to calculate the revised axial spacing on the body and the body panel geometry. If more than one segment exists, the revised meridional spacing geometry, YB and ZB, are read from TAPE8. At the end all geometric arrays in blank common are saved on TAPE7. The optional print of source panel control point coordinates, inclination angles and areas are performed here. A listing of this routine is found in Figure A-1(e) of this report.

See the discussion in Appendix B, Section B-3 regarding item 2 in Figure A-2 for the equivalent dimension of blank common at this point. The starting location indices defined in BODPAN and saved in labeled common DIMENS are

```
IXPT=1
IYPT=IXPT+NBODY
IZPT=IYPT+NBODY
ITH=IZPT+NBODY
IDEL=ITH+NBODY
IAR=IDEL+NBODY
IXC(IFU)=IAR+KFORX(1)+...+KFORX(IFU)  IFU=1,NFUS
IYC(IFU)=IAR+KX+KFORX(1)*KRADX(1)+...+KFORX(IFU)*KRADX(IFU)
IZC(IFU)=IYC(IFU)+KXKR
```

Subroutine references

IOREAD, BODPN2, IOWRIT

Called by

GEOM

A-8 Subroutine BODPN2

Subroutine BODPN2 performs the revision of the axial spacing on noncircular bodies and computes the body panel geometry of a

single segment. The x, y, and z coordinates of the cross sections of a segment are passed through the argument list as arrays. A listing of the routine is presented in Figure A-1(f) of this report.

The body panel geometry is established by a linear interpolation along body meridian lines of the y and z coordinates at the new axial stations. The interpolation is started with the first ring of panels in a segment and continued until the last ring of panels on the last segment is reached. The corner point coordinates, the control point coordinates, the inclination angles, and area are calculated for each panel in sequence. The calculation of the latter quantities are performed in routine PANEL from corner point information.

The panel control point coordinates, the panel dihedral angle θ , the panel incidence angle δ , the corner point coordinates and the panel areas are returned through the argument list to BODPAN where they are stored in blank common. Finally if the print option IPRT(2) \neq 0, the corner point coordinates are written on the output file.

Argument list

JP	panel number
XB(M)	x station of external geometry for Mth section in segment
XJ(J)	x station of revised axial spacing for Jth section in segment
YB(M,K), ZB(M,K)	y and z of external geometry for Mth section in segment and Kth meridional station
XYZ(JP,1), XYZ(JP,2), XYZ(JP,3)	XPT, YPT, and ZPT arrays of the x, y, and z coordinates of the control points of JPth panel
XYZ(JP,4)	dihedral angle THET of the JPth panel

XYZ(JP,5)	incidence angle DELTA of the JPth panel
XYZ(JP,6)	area of JPth panel
XC(J)	corner points of panels at Jth axial station
YC(J,K),	y and z corner points of panels at Jth axial
ZC(J,K)	station and Kth meridional angle
NFUSOR	number of external geometry stations on segment
KRAD	number of meridan lines on segment
KFUSOR	number of panel revised axial stations
NBODY	total number of body panels
IPRT	array of print controls

Subroutine references

PANEL

Called by

BODPAN

A-9 Subroutine BODVEL

Subroutine BODVEL organizes the looping through source panels to define corner geometry and compute panel influence coefficients. BODVEL loops through the number of source panels on each ring in the given body segment to set up the local panel corner coordinates. A listing of this routine is presented in Figure A-1(f) of this report.

The influence coefficients for each panel on all remaining panels is set up and computed in PANVEL. The influence coefficients are then generated for one ring of body panels on another ring. For each such block of coefficients, the influence normal to the panel and each of the three component velocities, u , v , and w , are saved. The block of normal coefficients is saved on TAPE9. If the coefficients correspond to a diagonal block in the total coefficient matrix (i.e. the influence of a ring on itself) the

L*U triangularization of the block is performed by PAS001 for later calculation use. In supersonic flow it is assumed that aft rings of panels have no influence on upstream panels. All blocks of coefficients above the diagonal blocks are thus assumed to be zero and not computed.

The descriptions of the variables in the argument list follow

XPT,YPT,ZPT	coordinates of panel control points
THET	array of panel inclination angles at control points
DELTA	array of panel incidence angles
AN	temporary array to contain the normal velocities to control point I
UB(1,IJ), UB(2,IJ), UB(3,IJ)	arrays of velocity components, u,v,w, at control points in body coordinate system
XC	x coordinates of leading and trailing edges of panel rings of segment
YC,ZC	y and z coordinates of body panel corner points of segment
KFUSOR	number of axial stations defining segment
IFU	segment index
IXZSYM	body XZ plane of symmetry indicator

Subroutine references

IOWRIT, PANVEL, PAS001

Called by

VELCMP

A-10 Subroutine BSHOCK

Subroutine BSHOCK computes the nonlinear shock wave shape emanating from the store or fuselage nose produced by an arbitrary body at angle of attack along a given meridian, PHIS(J). Three options are available depending on the value of NSHOCK (input items 14 or 61) for the choice of where the meridional traverses are made. Single traverses, evenly distributed traverses, and user specified locations may be used to define polar shape of the shock wave. A listing of the routine is presented in Figure A-1(g) of this report.

The methods used to generate the nonlinear position of the shock wave along a single traverse are developed in Section 4.1.2 of Reference 3. Use is made of the work of Reference 2. The axial scan for the maximum radial velocity behind the linear shock wave is computed for a fixed interval equal to half the distance from the nose to the body shoulder. This approximate interval must be used to account for the saw tooth behavior of the velocity field. The three-dimensional effects associated with angle of attack are accounted for by two means. In computing the local radial velocities along a traverse, the perturbation components must be rotated into wind axes to avoid including angle of attack components directly in the radial velocities as follows

$$u_w = u_s \cos \alpha_c - v_s \sin \alpha_c \sin \phi_R + w_s \sin \alpha_c \cos \phi_R + 1.0 \quad (A-2)$$

$$v_w = v_s \cos \phi_R + w_s \sin \phi_R \quad (A-3)$$

$$w_w = -u_s \sin \alpha_c - v_s \cos \alpha_c \cdot \sin \phi_R + w_s \cos \alpha_c \cdot \cos \phi_R \quad (A-4)$$

and second, the assumption the Mach cone rotates rigidly about the body with angle of attack is modified in accordance with reference 2 as follows.

$$\theta = \theta_s + \alpha_c (1 - \epsilon_\alpha) \cos \phi \quad (A-5)$$

where θ is the shock angle propagating from the nose, θ_s is the nose limited shock angle at zero angle of attack, α_c is the included angle of attack, ϵ_α is Mach number and nose cone angle dependent correction from Reference 2, and ϕ is the polar angle around the cone of the traverse. Tables of RSHK and XSHK for each of the polar traverses are the primary output of this routine.

This routine is used in two ways. For the fuselage, the shock shape is computed at the angle of attack of the body. The traverses are computed over the entire field of interest and include the corrections for angle of attack. For the stores, the shock shape is computed at zero angle of attack for only the first quadrant. The remaining shape is derived from symmetry. The angle of attack correction of Equation (A-5) is then applied to the zero angle of attack shape for the local conditions of each of the elliptic stores.

The descriptions of the parameters of the argument list are as follows:

RINIT	minimum radius at which shock shape search is initiated
PHSHK	for NSHOCK=0, angle at which shock shape is generated for NSHOCK<0, maximum meridional angle to which shock shape is calculated on even spacing
THSHK	limiting shock wave angle at nose measured from x-axis, θ_s

Subroutine references

FLDVEL

Called by

WDYBDY, STORIO

A-11 Subroutine CONFIG

Subroutine CONFIG is used to input the geometrical description of the external shape of the noncircular fuselage or elliptic stores. A listing of the routine is presented in Figure A-1(i) of this report. The routine first reads the configuration reference area from the input file if $J0 \neq 0$, otherwise the reference area is set equal to unity.

If $J2 \neq 0$, the body external geometry data is read from the input file according to the specified body option for each of NFUS body segments. For arbitrary cross-sections, the y and z ordinates of the body segment are read. For circular or elliptic sections, the particular combination of body area, radius, semi-major or minor axes, or elliptic ratio requested may be read.

In addition, the area at each axial station is computed. The maximum cross-section area is also saved. The description of the single argument is as follows:

SFUS array to hold the y and z ordinates of the arbitrary cross-section data for $J2=1$

Subroutine references

ASECTN

Called by

GEOM

A-12 Subroutine DOUBLT

Subroutine DOUBLT calculates coefficients used in the determination of the line doublet strengths. They occur as terms in Equations (I-27) and (I-28) of Reference 1. The relation of the coefficients to perturbation velocities, $u_{B,d}/V_\infty$ and $v_{B,d}/V_\infty$, induced by a number of line doublets distributed along the body centerline is shown in the first two of Equation (I-30) in which the coefficients occur as the multipliers of $K_{d,n} \cos \theta$. A listing of the subroutine is presented in Figure A-1(j) of this report. Section I-2.2 of Reference 1 should be referred to for further details concerning the doublet strength calculations.

For a specified control point, x_B , r_B , and singularity origin ξ , the subroutine calculates quantities U and V according to the following equations.

$$U = \beta \sqrt{\left(\frac{x_B - \xi}{\beta r_B}\right)^2 - 1} \quad (A-6)$$

$$V = -\frac{\beta^2}{2} \left[\cosh^{-1} \left(\frac{x_B - \xi}{\beta r_B} \right) + \left(\frac{x_B - \xi}{\beta r_B} \right) \sqrt{\left(\frac{x_B - \xi}{\beta r_B}\right)^2 - 1} \right] \quad (A-7)$$

At the beginning of the subroutine a test is performed to determine if the control point is ahead of the Mach cone from the doublet origin. If so, U and V are set to zero and control is returned to the calling program.

The following table of definitions contains most of the variable names used in the subroutine:

BETA $\beta = \sqrt{M^2 - 1}$
 RFIELD r_B ; radius of body at control point
 TX t ; location on body axis of doublet origin,
 positive measured from tip of nose
 U coefficient defined by Equation A-6
 V coefficient defined by Equation A-7
 XFIELD x_B ; x location of control point, positive
 measured from tip of nose

Called by
 BDYGEN

A-13 Subroutine DPCOEF

Subroutine DPCOEF calculates the coefficient matrix of the set of simultaneous boundary condition equations which are to be solved for the constant u-velocity panel singularity strengths. A listing of the subroutine is presented in Figure A-1(k), and a flow chart in Figure A-5 of this report.

The elements of the matrix are the aerodynamic influence coefficients described in Section 3.3.4 of Reference 3. They occur indirectly in the summation terms in the left-hand side of Equations (24), (25), and (26) of that reference. The actual coefficients which the subroutine calculates, $FVN(v,n)$, are related to the summation terms through the panel strengths, u_{+n}/V_∞ , by the following equations in which n is the index of the influencing panel and v is the control point index:

$$\frac{w_{w,v,n}}{V_\infty} \cos \phi_v - \frac{v_{w,v,n}}{V_\infty} \sin \phi_v = \frac{u_{+n}}{\pi V_\infty} FVN(v,n) \quad v = 1, 2, \dots, N_{PANLS}$$

$$\frac{v_{w,v,n}}{V_\infty} = \frac{u_{+n}}{\pi V_\infty} FVN(v,n) \quad v = NIP, NIP+1, \dots, N2$$

$$\frac{v_{N,v,n}}{V_\infty} = \frac{u_{+n}}{\pi V_\infty} FVN(v,n) \quad v = N2P, N2P+1, \dots, NPTOT$$

for $n = 1, 2, \dots, NPTOT$.

The subroutine consists of three double DO loops. The first loop uses subroutine VELWP1 to calculate the influence of the wing panels at the wing, pylon, and fuselage control points. The second loop is bypassed if there is no pylon, $NPY=0$. If a pylon is present, the influence coefficients for the pylon panels are calculated by means of subroutine VELPP1. The third double loop is bypassed if there is no fuselage, $NFU=0$. Otherwise, the influence coefficients for the fuselage panels are calculated using subroutine VELBD1.

Within each outer loop are three inner loops in series, which fix the control point location on the wing, pylon, or fuselage, respectively. On the flow chart, only the first occurrence of the first inner loop is shown in detail, which includes the call to subroutine VELWP1. The remaining inner loops have the same logical structure and are not shown.

If the control point is located on a wing or a fuselage panel, the influence coefficient is the component normal to the panel surface at the control point. Thus, the wing coefficients are rotated through the panel dihedral angle using quantities previously calculated in subroutine WLYOUT. The fuselage coefficients are rotated through the panel orientation angle using quantities calculated in subroutine BLYOUT.

Subroutine references

VELBD1, VELPP1, VELWP1

Called by

LDCAIC

A-14 Subroutine DPRHS

Subroutine DPRHS calculates the right-hand side vector of the set of simultaneous boundary condition equations which are to be solved in order to determine the constant u-velocity panel singularity strengths. The boundary conditions are specified in Equations (24), (25), and (26) of Reference 3. A listing of the subroutine is presented in Figure A-1(k) and a flow chart in Figure A-6 of this report.

The major portion of the subroutine is devoted to evaluating the externally induced perturbation velocities, $u_{wi,v}/V_\infty$, $v_{wi,v}/V_\infty$, and $w_{wi,v}/V_\infty$, at all of the wing, pylon, and fuselage control points.

The first section calculates velocities induced at wing and pylon control points by the circular fuselage line sources, sinks, and line doublets if a circular fuselage is present (NFU=1). A control point is located in the fuselage coordinate system and subroutine VELCAL is called to calculate the velocities at this point. These velocities are summed in the UEI, VEI, and WEI arrays.

The next section calculates velocities induced at wing and pylon control points by the noncircular fuselage source panels if a noncircular fuselage is present (NFU=2). Data for the fuselage are first restored to blank common from TAPE10 through FRSTRT and indices defining the beginning of the various arrays are defined. All of the wing and pylon control points are then located in the fuselage coordinate system. The velocities at these points are calculated by calling subroutine FLDVEL.

Next, the perturbation velocities induced by the wing and pylon thickness source panels are calculated by means of subroutines VELWT1 and VELPT1. The effects included are wing

source panels on wing, pylon, and fuselage control points and pylon source panels on wing and fuselage control points. If a pylon is not present, NPY=0, or the fuselage is not present, NFU=0, calculations involving the pylon or the fuselage are omitted.

The last three loops in the subroutine calculates the right-hand sides of the equations. If the pylon is located below the fuselage centerline, CENTER=TRUE, VEI is set to zero for all pylon control points.

It should be noted that if the control point is located on the wing or on the fuselage, dihedral effects are included in calculating the velocity normal to the panel surface.

Subroutine references

FLDVEL, FRSTRT, VELCAL, VEIPT1, VELWT1

Called by

LDCALC

A-15 Subroutine FLDVEL

Subroutine FLDVEL is used to organize the computation of the u, v, w velocity components at the field points XFP, YFP, ZFP. This routine initializes all velocities to zero and computes the locations of the required geometric and strength arrays in blank common for the fuselage or store at hand. If the configuration models the fuselage with inlets, variable INLET is initialized to TRUE to indicate presence of inlet panels. It then performs the looping for the number of segments and the number of rings in each segment to sum the component velocity contributions at each field point. A listing of the routine is presented in Figure A-1(m) of this report.

The descriptions of the parameters in the argument list follow:

XFP,YFP,ZFP	arrays of coordinates of field points in coordinate system of body panels at which component velocities are computed
SVN	temporary array of length NFLD used to test for zero influence at field point
LSKP	temporary logical array of length NFLD used to test for zero influence of ring of panels at field point
U,V,W	arrays of component velocities computed for influence of body at field points
NFLD	number of field points
ID	array containing the same variables in the same order as in common DIMENS
IG	index specifying IGth strength solution, GB, to be used

Subroutine references

FLDVL2

Called by

BSHOCK, DPRHS, INLSHK

A-16 Subroutine FLDVL2

Subroutine FLDVL2 computes the three components of velocity induced at specified field points by the source panels of a given ring of body panels. The field point is assumed to have no incidence or inclination relative to the flow. A listing of the routine is presented in Figure A-1(m) of this report.

The routine first initializes the field point inclination and incidence transformations to zero. For each of the influencing

panels on a ring the control point coordinates, inclination and incidence angles and corner points in the local panel system are defined. For each panel β_ℓ is initialized to β_0 . For panels used to model inlet openings β_ℓ is set to the minimum of β_0 and BTINLT. Further, if an inlet panel slope exceeds BTINLT, β_ℓ is set to $0.99/\tan\delta$. For each of the field points the influence of the panel on the field point is computed, multiplied times the panel strength and summed.

To minimize computational time FLDVL2 tests whether each ring of panels contributes to the total velocity at a given field point. For each point the following sum is made for each panel on the ring

$$SVN(I) = UB^2 + VB^2 + WB^2$$

where UB, VB, WB are the influence coefficients of a panel at the Ith field point. If the net influence for a complete ring SVN is equal to zero the logical variable LSKP(I) for that field point is set .TRUE. and all further calculations at that point are suppressed. This is based on the assumption that at supersonic speeds once a point is ahead of the Mach waves from a ring, the influence of that ring and all subsequent rings will vanish.

The descriptions of the parameters in the argument list follow:

XPT,YPT,ZPT	arrays of the coordinates of the source panel control points for the entire body
THET	array of inclination angles for panels
DELTA	array of incidence angles for panels
GB	array of panel strengths
XFP,YFP,ZFP	arrays of coordinates of field points
U,V,W	arrays of orthogonal velocity components at panels in x, y, and z directions

SVN	temporary array used to test influence of ring on point
LSKP	temporary array used as logical indicator of no further influence at point
NFLD	number of field points
XC,YC,ZC	arrays of coordinates of panel corners for segment
KFUSOR	number of axial station bounding panels in segment
IXZSYM	body symmetry indicator
JR	number of panels in ring J
JG	starting offset index of first panel in ring
L	index of trailing x-station in segment

Subroutine references

PANVEL, INLTST

Called by

FLDVEL, IMAGEV

A-17 Subroutine FRSTRT

Subroutine FRSTRT is used to save or restore required program information for the source paneling method to restart a configuration analysis. The routine is set up to allow storage of the information from more than one configuration on the same file. A listing of the routine is presented in Figure A-1(n) of this report. Six options are available based on the information to be stored or retrieved and where the information is to reside. They and the functions they perform are

KODE	DESCRIPTION
1	saves control integers and arrays in blank common
2	restores control integers and arrays in blank common

- 3 saves above information and AIC, U, V, and W
 velocity matrices
- 4 restores above information and AIC, U, V, and W
 velocity matrices
- 5 restores control integers and arrays stored
 under either option 1 or 3 into starting core
 location in blank common. All arrays are copied
 into blank common rather than into original
 labeled commons
- 6 restores information in manner of KODE=5 and reads
 past velocity matrices stored under option 3 to
 position file at next record

The information saved under KODE=1 consists of all the variables in labeled commons DIMENS, PARAM, BOPTNS, BGEOM, HEAD, and BSHOCK, and the first NTAP7 variables in blank common. The later set are also saved on TAPE7. If the configuration contains an inlet, the variables in common BINLET and BINSHK are also saved. In copying the velocity matrices under KODE=2, the arrays are first copied from TAPE8 or TAPE9 into temporary arrays in blank common and then onto the output file IO. The last two options are used in Program II to stack multiple configurations end-to-end in blank common. Provision has been made for only one configuration with an inlet. Variables from commons BINLET and BINSHK are copied back into those arrays under all KODE options. During this data retrieval three indices used to locate the control variable arrays are saved.

IDO (=LASTA+1) first location in blank common of variables
 contained in labeled commons DIMENS, PARAM,
 BOPTNS, BGEOM, and TITLE in order

ISKO (=IDO+571) first location in blank common of variables
 contained in labeled common BSHOCK

IAO (=ISK0+240) first location in blank common of geometric and strength arrays previously saved on TAPE7

The descriptions of the parameters in the argument list are:

IO external file unit number onto which the data is stored or retrieved in unformatted form

KODE optional index selecting information to be read or written to file IO; see above descriptions

LASTA last location in blank common currently defined

Subroutine references

IOREAD, IOWRIT

Called by

WDYBDY, STORIO, DPRHS, WRFILE

A-18 Subroutine FUSEIO

Subroutine FUSEIO reads and prints the input data which describe the circular fuselage (NFU=1) and calculates the line source and doublet distributions as described in Appendix I of Reference 1. A listing of the subroutine is presented in Figure A-1(o) and a flow chart in Figure A-7 of this report.

The subroutine first reads in and prints input items 5, 6, 7, and 8 which consist of the fuselage length, the maximum radius, and the polynomials specifying the fuselage shape. Next, the data used to lay out the body interference panels, input items 9 and 10, are read and printed. Subroutine BDYGEN is then called for the purpose of calculating the source and doublet distributions. The fuselage shoulder location is next found and finally

subroutine SHKSHP is called to calculate the nose shock wave shape.

Subroutine references

BDYGEN, SHKSHP

Called by

LDCALC

A-19 Subroutine GEOM

Subroutine GEOM organizes the reading of the noncircular body input and the calculation of the source panel geometry arrays. This routine is used to input both the noncircular fuselage and the elliptic store panel geometry. A listing of the routine is presented in Figure A-1(p) of this report.

The specification of the input describing the body paneling is split in two phases by GEOM. In the first phase the control parameters and the geometric arrays describing the external shape of the body are read. The external geometry arrays are read by a call to CONFIG. This geometry defines the external shape independently of the paneling used. It may optionally be used to specify panel corner coordinates. In the second phase the control parameters, additional arrays and inlet data required are read which define the subdivision of the external shape into panel coordinates. The routine NEWRAD is called to perform the interpolation necessary to redefine the meridional spacing of the panels. The routine BODPAN is called to perform the interpolations for new axial spacings of panels and to calculate control point coordinate and inclination information.

This routine also computes the number of panels to be generated and the allocation of array space in blank common to be used. The total number of axial stations, meridional angles used to

define panel corners and the total length of blank common required are compared against dimensioned values as check on input problem size.

Subroutine references

BODPAN, CONFIG, NEWRAD

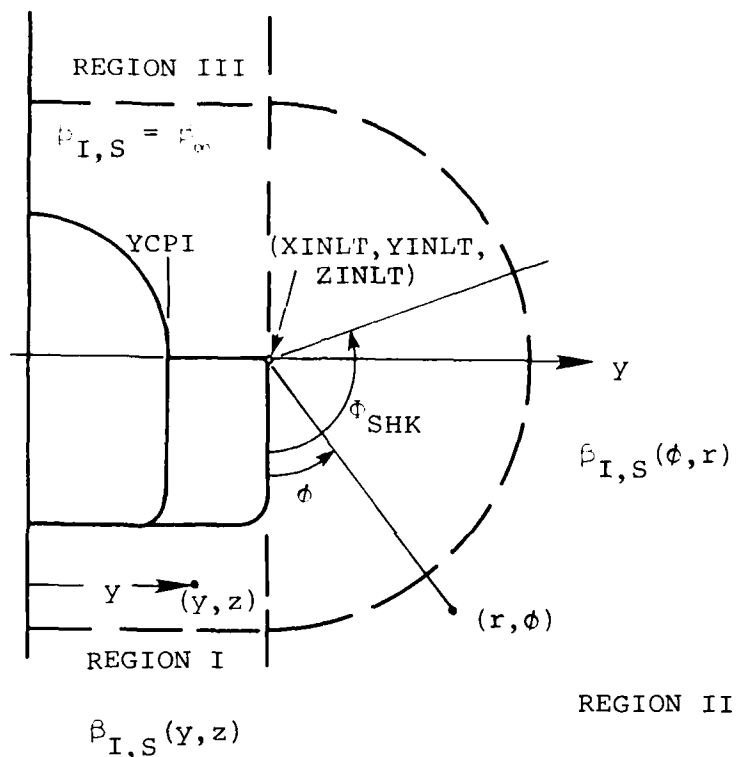
Called by

WDYBDY, STORIO

A-20 Subroutine INLSHK

Subroutine INLSHK computes the nonlinear shock wave shape emanating from a ramp type inlet shown in Figure 12 of Volume II. The table of shock locations is produced in a manner analogous to that used in BSHOCK to generate the shock shape about the body nose with the exceptions that only the influence of the modified panels across the inlet are felt and the shock propagates from the leading edge of the ramp. The detailed explanation of the inlet shock is presented in Section 4.4.2 of Reference 3. A listing of the routine is presented in Figure A-1(r) of this report.

The generation of the traverses used to locate the first influence and integrate the nonlinear shape uses the same model and equations detailed for BSHOCK. Additional assumptions are made about the body in generating the traverses regarding the shape of the ramp inlet. Field points aft of the inlet are assumed to lie in the three regions relative to XINLT, YINLT, ZINLT as shown in the following sketch.



In region I inside and below the inlet, traverses are carried out parallel to the XZ plane with subsequent interpolation in the y-direction to find the first inlet shock influence, $\beta_{I,S}$. In region II, outboard of the inlet, traverses are calculated along radial lines from $(XINLT, YINLT, ZINLT)$ from $\phi = 0^\circ$ to $\phi = \phi_{SHK}$. The last traverse at $\phi = 180^\circ$ is assumed such that $\beta_{I,S} = \beta_\infty$. In region III inboard and above ϕ_{SHK} for the inlet, the flow is assumed equal to free stream for which $\beta_{I,S}$ is set to β_∞ .

NIS shock traverses are generated alternating first in Region I and then in Region II to define the inlet shock location. The shocks propagate from a starting point at $(XINLT, y, ZINLT)$ along a line at the angle ϕ from the vertical plane. The first shock is positioned at $y=YINLT$ and $\phi=0^\circ$. The second traverse propagates

from $y=YINLT$ at $\phi=PHISHK$. The third propagates from $y=0$ at $\phi=0^\circ$. The fourth is at $y=YINLT$ and $\phi=45^\circ$ and the fifth is at $y=YCPI$ and $\phi=0^\circ$. Additional traverses are laid out by subdividing region I between $y=0$ and $y=YCPI$ and region II between $\phi=0$ and $\phi=PHISHK$ with even increments.

The following are differences in the calculative procedure for the inlet and the nose shock shape. In scanning in the axial direction at a given Y,Z location, all values are referenced to $XINLT$, $YINLT(IRAD)$, and $ZINLT$. In computing the influence at field points the strengths of all panels except those designated as open or blocked inlet panels and additional adjacent panels on the inlet aft of the opening are set equal to zero. In integrating the traverses, no angle equivalent to the nose limiting shock angle, θ_s , is used. When estimating the shock location below the inlet in region I in the presence of partial blockage (mass flow ratios less than one), the shock is assumed to follow $BTINLT$ down the inlet face to the first blocked panel. A normal shock is assumed to exist moving the shock vertically down to the lower lip of the cowl. For the first step, thereafter, in the radial direction, the $\beta_{I,S}$ propagating from the inlet is set equal to the first computed value. The only restriction is that it be positive.

The description of the parameter in the argument list follows:

PHISHK maximum meridional angle about $YINLT, ZINLT$ to
which shock shape is calculated on even spacing

Subroutine references

FLDV2L, INLTST

Called by

WDYBDY

A-21 Function INLTST

Logical function INLTST determines whether the panel index in the argument is for an inlet panel. The value of the function is set to TRUE if the index is for an inlet panel and FALSE if it is not. In addition the logical variable OPEN is set to indicate whether the inlet panel is blocked or unblocked to flow. Three conditions are tested for. If no inlet panels exist INLTST and OPEN are set false. If an inlet panel exists the index I is compared to the table of possible inlet panel numbers, JINLT. If I is equal to one of the inlet panel numbers, INLTST is set true. If I is not an inlet panel number, INLTST is set false. If I falls in the subset of JINLT of unblocked panels, OPEN is true; otherwise OPEN is set false. A listing of this routine is presented in Figure A-1(t) of this report.

The description of the parameters in the argument list follows.

I	panel number index to be compared with table of possible inlet panel numbers, JINLT
OPEN	logical variable indicating whether an inlet panel is open or blocked. OPEN is TRUE if panel allows unblocked flow through panel

Called by

BODVEL, FLDVL2, PANEL, SOLVE

A-22 Subroutine INLXYZ

Subroutine INLXYZ scans the X,Y,Z coordinates of the inlet panel corners to find the coordinates to be used to define inlet

leading edge, lower cowl lip, and first axial station containing blocked panels. Nine values are computed. They correspond to the most outboard leading edge of the inlet panels, XINLT, YINLT, ZINLT, the most aft outboard trailing edge of the inlet panels, XINLTE, YINLTE, ZINLTE, the innermost y station of the inlet, YCPI, and the first axial station of blocked inlet panels, XCLOSD. If no inlet blockage exists, this value is set to inlet trailing edge XINLTE. In addition, the inlet mass flow ratio is computed from the ratio of exposed open frontal area of inlet panels, A_{open} , to total inlet frontal area, A_{total} . The mass flow ratio RVIVO is set equal to A_{open}/A_{total} . This routine is called once for each inlet panel. A listing of the routine is presented in Figure A-1(t) of this report.

The descriptions of the parameters in the argument list follow.

XIN, YIN, ZIN	coordinates of corner of inlet panel to be checked
FAREA	frontal area of panel
OPEN	logical variable indicating whether an inlet panel is open or blocked. OPEN is TRUE if panel allows unblocked flow through panel

Called by
PANEL

A-23 Subroutine INVER1

Subroutine INVER1 solves the system of simultaneous linear algebraic equations.

$$[A]\bar{X} = \bar{B}$$

This routine performs pivot searching during the solution of the general matrix, A. The right hand side is passed into INVER1 as

the N+1'st column in the matrix. The solution, X, also returns in that location. A listing of this routine is presented in Figure A-1(u) of this report. The routine is currently limited to 200 equations by internal dimensions. The descriptions of the parameters in the argument list follow.

A	coefficients of linear system of equations in first N columns; columns N+1 through N+NSYS contain multiple right-hand sides, B, on input and solutions, X, on return
NSYS	number of right hand sides
N	actual number of equations
NMAX	first dimension of A
MMAX	second dimension of A

Called by
LDCALC

A-24 Subroutine IOREAD

Subroutine IOREAD performs an unformatted read from external file, IO. NA consecutive elements of array, A, are read sequentially. This routine is used to specify a common interface to external files. A listing of this routine is presented in Figure A-1(u) of this report. The descriptions of the parameters in the argument list follow.

IO	external file reference number
A	array of numbers to be read
NA	number of elements of A to be read

A machine dependent version of IOREAD is available for CDC machines using input routine BUFFER IN by appropriate replacement of comment cards within the routine.

Called by

BODPAN, VELCMP, SOLVE, SMARCH, FRSTRT

A-25 Subroutine IOWRIT

Subroutine IOWRIT performs an unformatted write to external file, IO. NA consecutive elements of array, A, are written sequentially. This routine is used as a common interface to external files. A listing of this routine is presented in Figure A-1(u) of this report. The descriptions of the parameters in the argument list follow:

IO	external file reference number
A	array of numbers to be written
NA	number of elements of A to be written

A machine dependent version of IOWRIT is available for CDC machines using output routine BUFFER OUT by appropriate replacement of comment cards within the routine.

Called by

BODPAN, VELCMP, SOLVE, NEWRAD, FRSTRT, BODVEL

A-26 Subroutine NETCLC

Subroutine NETCLC calculates the net corner strengths for a given set of wing, pylon, or fuselage constant u-velocity or thickness panels. The net strength for a corner point is calculated by superposing the strengths of the four panels surrounding the point. Whenever a corner point lies on an exterior boundary or along a chordwise row where a break in sweep angle or dihedral angle occurs, surrounding panels are assumed to be present with zero strengths. The superposition scheme is

described in Section 3.3.7 of Reference 3. A listing of the program is presented in Figure A-1(v) of this report.

The panel strengths are passed to the subroutine as formal parameters in the array S, which is dimensioned NCW by MSW. The subroutine first stores this array in a new array P, leaving the first and last columns zero and inserting a zero column whenever a break in leading-edge or trailing-edge sweep angle or dihedral angle occurs. The polar angle acts as dihedral angle for a body interference panel. The first and last rows of P are also set to zero. These zero elements of array P correspond to panels of zero strength mentioned above.

The rest of the subroutine consists of a double DO loop in which the net corner strengths, DP, are calculated according to the following relation:

$$\begin{aligned} DP(I,J) &= P(I,J) - P(I+1,J) - P(I,J+1) + P(I+1,J+1), & (A-8) \\ I &= 1, NCW+1 \\ J &= 1, MSW+k+1 \end{aligned}$$

where k is the number of breaks in sweep or dihedral which occur over the specified set of panels.

The descriptions of the parameters in the argument list follow:

S	array containing the NCW*MSW panel strengths
DP	array containing the NCW1*MSW1 net corner strengths
NCW	number of panels in a chordwise row; also row dimension of S
NCW1	NCW+1; row dimension of DP
MSW	number of panels in a spanwise row on wing or pylon; number of panels in a ring of fuselage panels
MSW1	MSW+1

MSWK1	number of corner points in a spanwise row of wing or pylon panels; number of corner points in a ring of fuselage panels
PSILE	array containing leading-edge sweep angles for wing or pylon, polar angles for fuselage panels
PSITE	array containing trailing-edge sweep angles for wing or pylon, polar angles for fuselage panels
PHI	array containing dihedral angles for wing, polar angles for fuselage; zero array for pylon

Called by
NULYT

A-27 Subroutine NEWRAD

Subroutine NEWRAD is used to organize the revision of the noncircular body meridian line spacing for the source panels. This routine computes the number of meridional lines to be used for paneling on the half or full body. The allocation of arrays to be used for temporary storage, YB and ZB, are defined also. NEWRAD calls NEWRD2 for the revised meridional spacings for each of the NFUS body segments. If more than one segment exists, the revised ordinates, YB and ZB, are written on external file number 8. A listing of this routine is presented in Figure A-1(v) of this report.

Subroutine references

IOWRIT, NEWRD2

A-28 Subroutine NEWRD2

Subroutine NEWRD2 computes the revised noncircular body meridian line spacing of a given body segment. For each

segment, there are three options for redefining the meridian lines and the option to define the symmetric portion of a body. If $KRAD=0$, the meridian lines are not changed. If $KRAD$ is positive, the meridian lines are relocated at $KRAD$ equally spaced values of the meridian angle ϕ_k . If $KRAD$ is negative, the user defined values of ϕ_k are used. For each of the above options, new meridian lines may be defined from circular, elliptic, or arbitrary section input. A listing of this routine is presented in Figure A-1(v) of this report.

If the body has circular or elliptic cross section, the y and z coordinates are calculated at each station as follows:

$$\begin{aligned} y &= r \cos \phi \\ z &= z_c + r \sin \phi \end{aligned} \quad (A-9)$$

where z_c is the camber offset in item 19 of the input and the local radius r is defined as

$$r = \frac{1}{\sqrt{(\cos \phi / BY)^2 + (\sin \phi / AZ)^2}} \quad (A-10)$$

The parameters BY and AZ are the horizontal and vertical semi-axis of the ellipse. For the circular body, BY and AZ are equal to the radius and the above equation reduces to the circular radius.

If the body has an arbitrary cross section, the y and z coordinates are obtained by linear interpolation at the new values of the original y and z coordinates read in the program input items 20 and 21.

If the symmetry option is used, $IXZSYM=1$, the remaining coordinates for the second half of the body are defined. The meridian lines for the symmetric half of the body continue in counterclockwise fashion about the body. The y ordinates are the

negative of the first half of the body, while the z values remain the same.

The descriptions of the parameters in the argument list follow:

YB,ZB	y and z ordinates of the revised meridional spacing
PHIK(K)	ϕ_k , Kth revised meridian for new spacing, deg.
ZFUS(N)	z_c , camber offset of centerline at Nth axial station of segment
FUSBY(N), FUSAZ(N)	BY and AZ, horizontal and vertical semi-axes of ellipse at Nth axial station of segment
SFUS	array containing y and z for arbitrary cross section input option
NFUSOR	number of axial stations of segment
KRAD	number of meridian lines of revised spacing
NRAD	number of meridian lines of original input spacing
IXZSYM	symmetry option

Called by
NEWRAD

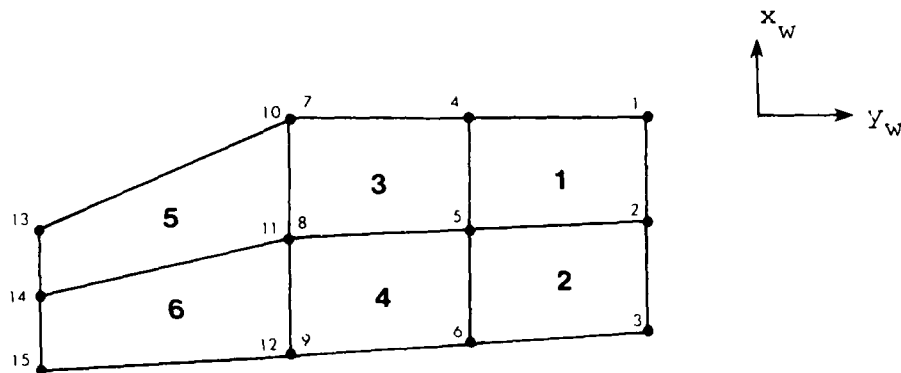
A-29 Subroutine NULYT

Subroutine NULYT selects a subset of constant u-velocity and wing and pylon thickness panel layout data to be saved as an input data set for Program II. The subroutine also calculates and saves the net strengths associated with each panel corner. A listing of the subroutine is presented in Figure A-1(w), and a flow chart in Figure A-8.

The data stored in the new arrays describe a grid of corner points representing the panel layout, thus eliminating some duplication. For example, a corner which is the junction of four

panels is specified four times in the panel coordinate arrays, only once in the corner system. Similarly, the slope of the boundary of two panels adjacent in a chordwise row is saved only once in the new arrays. However, whenever a break in sweep or dihedral angle occurs, an extra chordwise row of points must be saved to accommodate the velocity calculations to be performed in Program II.

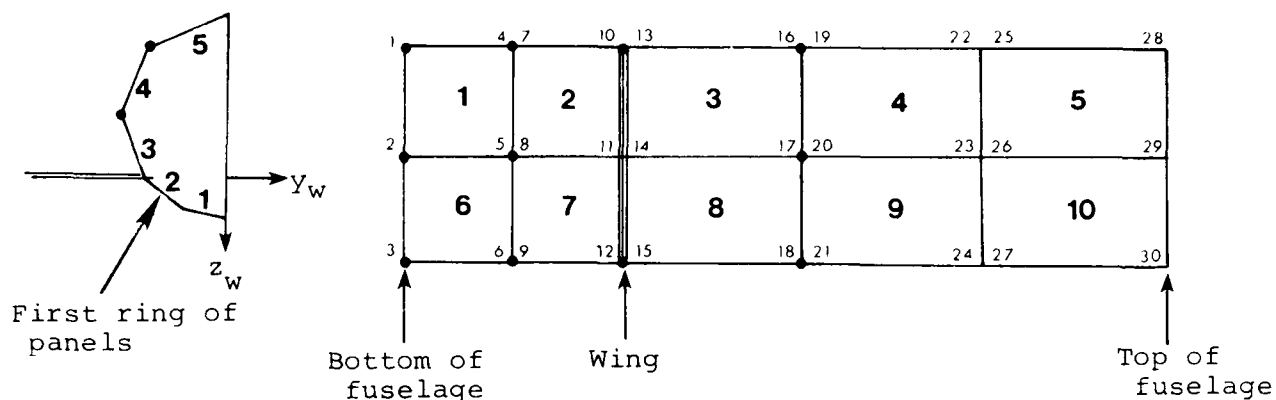
At the beginning of the subroutine indices needed to describe the new arrays are calculated. Next, as the flow chart indicates, data is stored for constant u-velocity panels on the wing. The sketch below illustrates the corner numbering convention as employed for a wing with one leading-edge sweep break and six panels. Panel numbers are in the center of the panels.



For each chordwise row of points, the variables YPT,ZPT,SPHI,CPHI are stored only once. Variables XPT and SWP are stored for all points. The slope and dihedral values used correspond to panels to the left of the points, except for an extra row of points which occurs at a break in sweep or dihedral. For this type of chordwise row (points 7,8,9 in the above sketch), SPHI, CHPI, and SWP correspond to panels to the right.

If a pylon is present, the subroutine next stores the corner data for pylon panels. These data are stored in the same arrays

following the wing corner data. Similarly, if a fuselage is present, the corner data for the fuselage panels is saved in arrays following the wing and pylon data. The correspondence between body interference panels and corner point numbering is shown in the sketch below in which NBD CR1=3, NBD CR2=2. One should note that an extra row of points is saved for each chordwise row of panels.



The subroutine next stores the data for wing and pylon source panels, using the same procedure as for wing and pylon constant u-velocity panels. However, the source panel data are stored in separate arrays.

The last section of the subroutine calculates, by means of subroutine NETCLC, the net strength associated with each corner point. Finally at the end of the routine, a factor of π which had been removed from the source panel thickness slopes for boundary condition calculations, is restored.

Subroutine references

NETCLC

Called by
LDCALC

A-30 Subroutine PANEL

Subroutine PANEL's purpose is to calculate direction cosines of the normal vector and the centroid, area, and inclination angles of an arbitrary quadrilateral panel. It is called to compute the geometric properties of each source panel on the noncircular body. A listing of the routine is presented in Figure A-1(y) of this report.

The four corners of the panel are numbered in a clockwise direction. A diagonal vector T_1 connects points 1 and 3, and a diagonal vector T_2 connects points 2 and 4. The normal vector N is obtained by taking the cross product of these diagonal vectors, and the direction cosines determined by calculating the projections of this vector in the body reference coordinate system. The plane of the panel is defined to be perpendicular to the normal vector and to pass through a point whose coordinates are the averages of the coordinates of the four input points. The input points are then projected into the plane of the panel, and transformed to the reference coordinate system. A new panel coordinate system ξ, η is introduced with the average point of the panel as origin. The coordinates of the centroid and the panel area are calculated in this new system, and the centroid transformed to the reference system. Two angles are used to define the panel orientation. The incidence ϕ is the angle between the x axis and the line of intersection with the panel of a plane passing through the x axis and perpendicular to the panel. The inclination θ is the angle between the y axis and the line of intersection of the panel with the yz plane. These two angles are calculated in terms of the direction cosines of the normal vector.

The descriptions of the parameters in the argument list follow:

J	panel row number
K	panel column number
NP	panel number
XYZ(NP,1),	array containing vectors of control points, XPT,
XYZ(NP,6)	YPT,ZPT, angles, THET and DELTA, and area for NPth panel
NBODY	total number of panels
XC,YC,ZC	array containing coordinates of corner points of panels
KFUSOR	number of axial stations in segment

Subroutine references

INLTST, INLXYZ

Called by

BODPN2

A-31 Subroutine PANVEL

Subroutine PANVEL organizes the calls to SORPAN for the calculation of the influence of a panel at a field point. This routine computes the transformations and rotations necessary to calculate the influence of an arbitrarily oriented panel at either a field point or at the control point of another arbitrarily oriented panel. A listing of the routine is presented in Figure A-1(z) of this report.

The routine first computes the combined transformations to rotate a panel or its image into the local panel system and back. If the same transformation is to be used for a number of calculations the logical variable, LZERO, is used to skip around this code in subsequent calls. The field point in question is rotated

into the panel coordinate system and a call made to SORPAN to compute the influence coefficient. If the body is symmetric (IXZSYM=0) the above calculations are repeated for the symmetric panel on the opposing side of the X-Z plane. The influence is summed and rotated back into the original body coordinate system.

The descriptions of the parameters in the argument list follow:

UB,VB,WB component velocity influence coefficients in body
 coordinate system at field point
AN resultant normal velocity coefficient of panel at
 a field point or at another arbitrarily oriented
 panel
IXZSYM body X-Z plane symmetry option

Subroutine references

SORPAN

Called by

BODVEL, FLDVL2

A-32 Subroutine PAS001

Subroutine PAS001 performs the L*U decomposition of the positive definite matrix, A. This routine performs no pivot search during decomposition. It does skip unnecessary calculations associated with off-diagonal zeroes. An error return is provided for encountering zero values on the diagonal. The decomposition procedure is equivalent to

$$A = \begin{bmatrix} 1.0 & & & & \text{zero} \\ L_{21} & 1.0 & & & \\ . & & . & & \\ . & & & 1.0 & \\ L_{n1} & . & . & L_{nn-1} & 1.0 \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} & . & . & u_{1n} \\ & u_{22} & & & . \\ & & . & & . \\ & & & . & . \\ \text{zero} & & & & u_{nn} \end{bmatrix} \quad (A-11)$$

The decomposed matrix is stored in the location of the original matrix. A listing of the routine is presented in Figure A-1(aa) of this report.

The descriptions of the parameters in the argument list follow:

A	positive definite matrix with nonzero diagonal elements
N	actual size of matrix, A
NER	diagnostic. If NER greater than zero, decomposition failed because $ A(NER,NER) < 10^{-20}$
ND	dimensioned size of A

Called by
BODVEL

A-33 Subroutine PAS002

Subroutine PAS002 solves the system of equations $[L*U] * X = B$ by forward and backward substitution. It is assumed that matrix, A, has been decomposed by routine PAS001 or equivalent so that A contains $[L*U]$. A listing of the routine is presented in Figure A-1(aa) of this report.

The descriptions of the parameters in the argument list follow:

A	coefficient matrix containing $[L*U]$
B	matrix containing right-hand sides of the linear system $[L*U] * X = B$. Contains X on output
N	actual size of $[L*U]$ matrix contained in A
NB	number of right-hand side vectors contained in the first NB columns of B
NDA	dimensioned size of A
NDB	dimensioned size of B

Called by
SMARCH

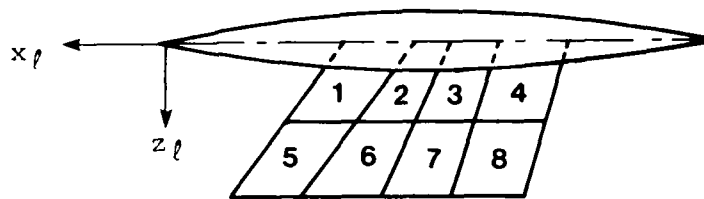
A-34 Subroutine PLYOUT

Subroutine PLYOUT reads in data which describe the geometric characteristics of the pylon and calculates quantities which specify the pylon constant u-velocity panels. The pylon input variables are shown in Figure 8 of Volume II. A listing of the subroutine is presented in Figure A-1(aa) and a flow chart in Figure A-9.

The first part of the subroutine reads in and prints input items 43, 44, and 45. The total number, MP, of pylon constant u-velocity panels is calculated. Next, the subroutine tests whether the pylon leading-edge and trailing-edge sweep angles are constant at all spanwise z-stations. If breaks in sweep occur, the indicator LVSP is set equal to one; otherwise, LVSP=0 and the quantity SLPDIF, the difference between leading-edge and trailing-edge slopes for a chordwise row, is computed outside the DO loops. The zero location of the pylon root chord is calculated, and the variables PLEX and CSIDE are initialized for laying out the first chordwise row of panels.

The remainder of the subroutine is a double DO loop within which panel leading-edge and trailing-edge slopes, corner coordinates, and control point coordinates are calculated. These quantities for the pylon are stored in arrays following the same quantities calculated by subroutine WLYOUT for the NPANLS constant u-velocity panels on the wing.

The following sketch shows the numbering convention associated with the pylon panels for a typical pylon-under-wing layout with four chordwise and two spanwise panels.



In the subroutine notation, the panel corners labeled left are those farthest from the pylon root chord.

Called by
LDCALC

A-35 Subroutine PYTHIN

Subroutine PYTHIN reads in the pylon thickness data, input items 46, 47 and 48. A listing of the subroutine is presented in Figure A-1(bb) of this report.

The number of panels in a chordwise row, NCPS, and the number of chordwise rows, MSPS, are first read in along with an index, NUNIP, which indicates whether the thickness distribution is similar at all spanwise stations. The subroutine then reads input item 47. Next, if NUNIP=1, the values of $\tan \theta_p$ are read in for the first chordwise row and then the values of $\tan \theta_p$ for the other rows are set equal to those of the first row. If the distribution is not similar, NUNIP=0, the values of $\tan \theta_p$ for all rows are read in.

Called by
LDCALC

A-36 Subroutine RACKIO

Subroutine RACKIO reads and prints the data which describe and locate the rack and calculates the rack source and doublet distributions. The rack model is limited to description as a circular body. A listing of the routine is presented in Figure A-1(cc) and a flow chart of subroutine RACKIO is presented in Figure A-10 of this report.

The subroutine first reads and prints the dimensional lengths and locations of the rack, and the polynomial coefficients which describe the shape. The rack is then located in the wing coordinate system. Both the line source and doublet distributions for the rack are calculated through a call to BDYGEN. The rack shoulder is located from the first zero slope. Lastly, the rack shock wave shape is computed in a call to SHKSHP.

Subroutine references

BDYGEN, SHKSHP

Called by

LDCALC

A-37 Subroutine SHAPE

The purpose of this subroutine is to calculate the body radius and surface slope at a specified axial station. The body shape is specified by a series of polynomials of the form of Equation (1) of Volume II. A flow chart of subroutine SHAPE is presented in Figure A-11 and a listing of the subroutine in Figure A-1(cc).

The calculation performed by this subroutine consists of two steps. The first step is to determine which of the NS polynomials describes the shape at the value of X where the radius and surface

slope are required. Once this is determined, the appropriate set of coefficients is used in Equation (1) of Volume II to determine r/ℓ . The value of dr/dx is found by differentiating Equation (1).

$$\frac{dr}{dx} = \frac{C_7}{2} \left[\frac{2C_2 \frac{x}{\ell} + C_3}{\sqrt{C_2 \left(\frac{x}{\ell}\right)^2 + C_3 \frac{x}{\ell} + C_4}} \right] + C_5 + 2C_6 \frac{x}{\ell} \quad (A-12)$$

It should be noted that r/ℓ and dr/dx are calculated using the coefficients of the NSth polynomial if x/ℓ is greater than $XE(NS)$.

The quantities in the parameter list are:

X	value of x/ℓ at which radius and surface slope are to be calculated
NS	number of polynomials describing body shape
XE	array containing values of x/ℓ for the end points of the NS polynomials
C	array containing the coefficients of the NS polynomials
R	calculated value of r/ℓ at $x/\ell = X$
DRDX	calculated value of dr/dx at $x/\ell = X$

Called by
BDYGEN

A-38 Subroutine SHKSHP

Subroutine SHKSHP calculates the nonlinear shape of the shock wave produced by an axisymmetric body at zero angle of attack. The calculations performed here are based on the equations presented in Section 4.1.1 of Reference 3. A listing of this routine is presented in Figure A-1(dd) of this report.

The computation sequence used here is to incrementally compute the change in β with distance from the centerline and numerically integrate the shape radially. The procedure starts at the nose and initializes the slope of the shape to the maximum value BTNOSE prescribed through the input. A new radial distance is prescribed, and an axial search for the maximum radial velocity performed. With that velocity the local Prandtl-Meyer turning angle, local Mach number, and new shock slope, β_{vi} , are computed. The new axial location of the shock shape is computed from the average β over the interval step

$$x_{SHK_i} = x_{SHK_{i-1}} + \frac{1}{2} (\beta_{vi} + \beta_{v_{i-1}}) \Delta r \quad (A-13)$$

The integration procedure is repeated until the calculated β_v approaches the free stream value as $(1 - \beta_{vi}/\beta_\infty) < 0.01$ or a maximum number of intervals of 50 is reached before terminating.

The descriptions of the parameters in the argument list follow:

NC	maximum number of axial steps used to scan for maximum radial velocity
SX(J)	axial station of Jth line source
SS(J)	line source strength at Jth axial station
BETA	$\sqrt{M_\infty^2 - 1}$, value of free stream
RMAX	maximum body radius; used to determine initial step size, Δr
BTNOSE	limiting value of β at nose; input
NSHK	number of values computed in shock shape table
XSHK	array containing axial location of shock relative to nose
RSHK	array containing radial location of shock relative to centerline

Called by

FUSEIO, RACKIO, STORIO

A-39 Subroutine SMARCH

Subroutine SMARCH solves for the source panel strengths using a ring by ring marching technique. A listing of the subroutine is presented in Figure A-1(dd) of this report.

SMARCH is organized to solve the general source panel solution for a body in supersonic flow:

$$[A]\gamma_B = V_B - [A_I]_B \quad (A-14)$$

where $[A]$ is the aerodynamic influence coefficient matrix partitioned into blocks of the coefficients of one ring on another; γ_B are the panel strengths; V_B are the boundary condition normal velocities in the absence of an image body; and $[A_I]$ is the influence coefficient matrix of the image body on the real body control points. No image store effects will be considered in any solutions in the first program. The solution proceeds in blocks of equations, with only those blocks of equations on or below the diagonal computed and saved on TAPE9. The first block corresponding to the influence of a ring on itself is read from TAPE9 in L*U decomposed form. The solution for that ring is computed with PAS002. Subsequent blocks in column form are read and multiplied by the strengths of that ring and subtracted from the boundary conditions for following rings.

The descriptions of the parameters in the argument list follow:

GB	array of panel strengths, γ_B
VB	array of panel boundary conditions destroyed during solution

IA index of starting location in blank common of
 temporary A matrix
IMAGE logical indicator of presence of image body

Subroutine references
 IOREAD, PAS002

Called by
 SOLVE

A-40 Subroutine SOLVE

Subroutine SOLVE computes the source panel boundary condition for a noncircular body in the presence of a free stream angle of attack and roll angle and calls SMARCH for the solution for the panel strengths. A listing of the routine is presented in Figure A-1(ee) of this report.

The routine initializes the angle of attack parameters and allocates temporary storage in blank common for the arrays required during the calculation of panel strengths. The boundary conditions are defined as follows

$$V_B = \cos\alpha_C \sin\delta - \cos\delta (\sin\alpha_C \cos\phi_R \cos\theta + \sin\alpha_C \sin\phi_R \sin\theta) \quad (A-15)$$

The solution is then computed in SMARCH. A copy of blank common up through the panel strengths is then saved on TAPE7. SOLVE may be called for multiple angles of attack with each set of strengths saved sequentially after the other.

The description of the parameter in the argument list follows:

IALP index of the number of the IALPth boundary condition
 to be computed and saved. $IALP \leq 7$

Subroutine references

LOWRIT, SMARCH

Called by

WDYBDY, STORIO

A-41 Subroutine SORPAN

Subroutine SORPAN computes the three components of velocity induced at a specified control point by a constant source distribution on a quadrilateral panel having longitudinal taper and inclined at an angle delta to the free stream direction. This version has been specialized for only supersonic flow. This routine is based on the methods and equations presented in Reference 4. A listing of the subroutine is presented in Figure A-1(ff) of this report.

The descriptions of the parameters in the argument list follow:

UPM,VPM,WPM three orthogonal components of velocity in local panel coordinates induced by panel with control point XJ,ZJ at field point XI,YI,ZI

Called by

PANVEL

A-42 Subroutine SOURCE

Subroutine SOURCE calculates coefficients used in the determination of the line source strengths. They occur as terms in Equations (I-14) and (I-17) of Reference 1. The relation of the coefficients to perturbation velocities, $u_{B,a}/V_\infty$ and $v_{B,a}/V_\infty$, induced by a number of line sources distributed along the body centerline is shown in the first two of Equation (I-30) in which

the coefficients occur as the multipliers of K_n . A listing of the subroutine is presented in Figure A-1(gg) of this report. The subroutine is called by subroutine BDYGEN and Section A-4 should be referred to for further details concerning the source strength calculations.

For a specified control point, x_B, r_B , and singularity origin, ξ , the subroutine calculates quantities U and V according to the following equations:

$$U = - \cosh^{-1} \left(\frac{x_B - \xi}{\beta r_B} \right)$$

$$V = \beta \sqrt{\left(\frac{x_B - \xi}{\beta r_B} \right)^2 - 1}$$

At the beginning of the subroutine a test is performed to determine if the control point is ahead of the Mach cone from the source origin. If so, U and V are set to zero and control is returned to the calling program.

The definition of the variable in the argument list is:

TX ξ ; location on body axis of source origin;
positive measured from tip of nose

Called by
BDYGEN

A-43 Subroutine STORIO

Subroutine STORIO reads and prints the data which describe and locate the multiple stores and organizes the calculation of the panel or line singularity strengths for both circular and elliptic bodies. The routine may read up to a total number of seven stores of either circular or elliptic shape. Several stores may share the data for the same shape. However, when elliptic stores are

considered, only two elliptic shapes are permitted with up to seven stores of that shape. A listing of the subroutine is presented in Figure A-1(gg) of this report. A flow chart of the routine is presented in Figure A-12.

The subroutine consists of three sequences of DO loops. The first reads and prints NSTRS cards containing the store number, shape, length, maximum radius, location relative to wing, and orientation. The second loop reads and prints NSHPT sets of shape data. If the shape is circular, items 57 through 59 of the input are read for each of the shapes. If the shape is elliptic, items 60 through 75 are read through a call to GEOM. The source panel geometry is computed and a temporary copy of all shape geometry data saved on TAPE11. The location of the store nose in the wing coordinate system is then computed for each of the stores.

The last major loop is a double DO loop over the number of shapes and over the number of stores. The outer loop is over the number of shapes to facilitate reading the panel geometry saved on TAPE11. In the inner loop on the number of stores, the store shape number is compared with the shape under consideration and the appropriate properties computed. For circular shapes, BDYGEN is called to compute the line source and doublet distributions, the shoulder location and shock shape are then calculated. For elliptic shapes, VELCMP is called to generate the influence coefficient matrix. Two calls to SOLVE may be made. For the first store of the shape the panel strengths are computed at zero degrees angle of attack and the nonlinear shock shape computed in BSHOCK. For each of the stores of that shape SOLVE is called again to compute the panel strengths at the angle of attack and roll of the fixed store. A copy of the store indices, geometry arrays, and strengths are then saved on TAPE10 by FRSTRT.

Subroutine references

BDYGEN, BSHOCK, FRSTRT, GEOM, SHKSHP, SOLVE, VELCMP

Called by

LDCALC

A-44 Subroutine SWNGIN

Subroutine SWNGIN reads in data required to describe the geometric characteristics of the wing and to lay out the wing constant u-velocity panels. A listing of the subroutine is presented in Figure A-1(ii) of this report.

The first part of the subroutine reads in and prints input items 35, 36, and 37, which consist of wing geometry data and quantities used to locate the trapezoidal-shaped elemental panels. If any nonzero dihedral angle is input, the logical variable ZDIHED is set equal to FALSE. Next, the wing twist and camber distribution, if any, is read, input items 38 and 39. Two indices, NTAC and NUNI, are first input. If NTAC=0 there is no twist and camber. The index NUNI indicates whether the twist and camber distribution is similar at all spanwise stations. If it is similar, NUNI=1, the values of $\tan \alpha_\ell$ are read in for the first row and then the values of $\tan \alpha_\ell$ for the other rows are set equal to those of the first row. If the distribution is not similar, NUNI=0, the values of $\tan \alpha_\ell$ for all rows are read in.

Called by

LDCALC

A-45 Subroutine THKLYT

Subroutine THKLYT calculates quantities which characterize the wing and pylon thickness source panels. These quantities are

stored in arrays in each of which the wing panel variables precede the pylon variables. All panel coordinates are expressed in the wing coordinate system which is shown in Figure 7 in Volume II. A listing of the subroutine is presented in Figure A-1(ii) and a flow chart in Figure A-13.

The first part of the subroutine calculates the layout of the wing panels. After the variables CSIDEP, SLPDIF, ZLER, and WLEX are initialized for the first chordwise row of panels, the remaining calculations are performed within a double DO loop. The outer loop index, I, specifies the chordwise row and the inner loop index, K, the panel location in the Ith row. Within the inner loop the panel leading-edge and trailing-edge slopes, the sine and cosine of the dihedral angle, and the corner coordinates are calculated and stored. The panels are numbered consecutively in chordwise rows beginning with panel number one of row one adjacent to the wing root chord at the leading edge. The sequence proceeds in increasing numbers to the trailing edge, then back to the leading edge for the second chordwise row. The process continues until the last panel, numbered MS, is located adjacent to the wing tip at the trailing edge.

If a pylon is present (NPY=1), the remainder of the subroutine calculates the panel leading-edge and trailing-edge slopes and the corner coordinates for the pylon source panels. The procedure used differs very little from the wing panel calculations. Values of YPL, ZPL, and LVSP, previously calculated in subroutine PLYOUT, are used. Also, the initial value of PLEX depends upon the pylon location; the index IP is tested for this purpose. The numbering convention associated with the pylon thickness panels is the same as that used for pylon constant u-velocity panels. It is described in Section A-34. In describing corner coordinates for both wing and pylon panels, the corners closer to the respective root-chords

are designated right corners; those farther from the root-chords are designated left corners.

Called by
LDCALC

A-46 Subroutine THKOUT

Subroutine THKOUT prints the slopes of the wing and pylon thickness distributions which were read in as items 42 and 48 of the input data, see Section 3.2.2. After the thickness slopes are printed, they are divided by π and saved in a combined array, DZDX, for subsequent velocity calculations. A listing is presented in Figure A-1(jj) of this report.

Called by
LDCALC

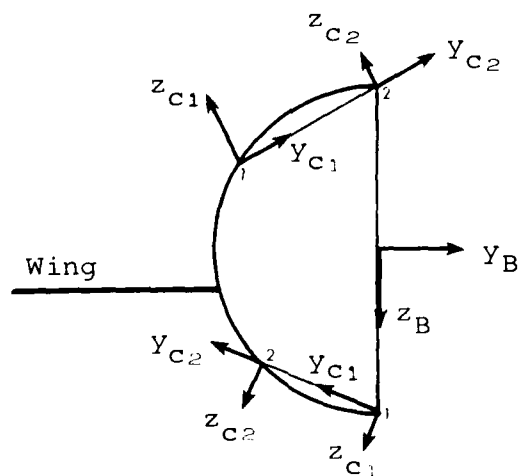
A-47 Subroutine VELBD1

Subroutine VELBD1 is used to obtain the single-panel u-velocity panel influence coefficients which occur indirectly in Equations (24), (25), and (26) of Reference 3. Section A-13 of this report should be consulted for further details concerning these coefficients. A listing of the subroutine is presented in Figure A-1(kk), and a flow chart in Figure A-14 of this report. The subroutine uses quantities calculated in subroutine BLYOUT which is described in Section A-5. The wing coordinate system is shown in Figure 7 in Volume II.

At the beginning of the subroutine the logical variable PYPNL is set equal to FALSE, the velocity totals UP, VP, and WP are initialized to zero, and the panel leading-edge and trailing-edge

slopes, EM , are defined as zero. In the remainder of the subroutine the influence functions for the four corners of the i th panel are calculated and superposed. The superposition scheme is described in Section 3.3.4 of Reference 3 and that reference should be consulted for further details. In the corner numbering convention for fuselage panels corner one is the left front, corner two the right front, corner three the left rear, and corner four the right rear panel corner. The right corners are clockwise from the left when viewed from the rear.

Next in the subroutine the corner influence function totals TU , TV , and TW are initialized to zero and a test is performed to determine if the point at which velocities are to be calculated lies ahead of the panel leading edge. If so, all calculations for the panel are skipped. If the point is not ahead of the leading edge, a test is performed next to determine in which fuselage quadrant the panel lies. As the flow chart indicates, two similar but distinct transformation and superposition procedures are followed, depending upon the panel location. In each procedure, the field point is first located relative to corner one in a corner coordinate system which is shown in the sketch below. Each panel corner has an associated coordinate system. The x_c axis, not shown in the sketch, is positive to the rear.



If corner one is in the upper left quadrant the sign of the y_c coordinate of the field point is reversed and subroutine VELO1 is called to calculate the influence of the corner on the image of the point with respect to the x_c, z_c plane. The sign of V, which is the returned influence function in the y_c direction, is then reversed. The functions U,V,W are resolved back into the wing system and superposed in the same manner as that used for wing panels with positive sweep (see Figure 4, Reference 1). Panels in the lower left quadrant are treated in the same manner as wing panels with negative sweep. No further coordinate change is necessary and subroutine VELO1 returns U,V, and W which are resolved into the wing system and superposed.

Next, in each procedure, the influence of the mirror image of corner one with respect to the aircraft vertical plane of symmetry is calculated. This is accomplished by the equivalent method of calculating the direct influence of corner one on the field point image. Following the call to subroutine VELO1 the sign of V is reversed in the superposition.

Corner one calculations are repeated in a similar manner for corners two, three, and four, but only corner one is detailed in the flow chart. After superposition of the four corner influence functions for the panel is completed, the influence coefficients for the fuselage panel at the given control point are returned by the subroutine.

Subroutine references

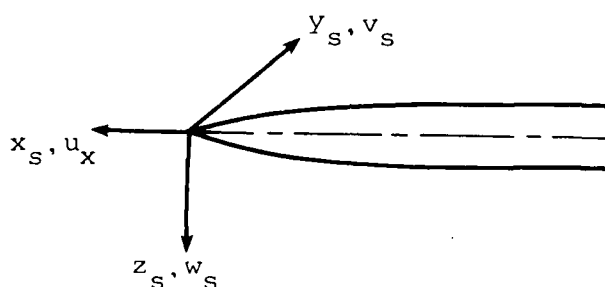
VELO1

Called by

DPCOEF

A-48 Subroutine VELCAL

Subroutine VELCAL calculates perturbation velocities at a given field point due to the fuselage and store source and doublet distributions. A listing of the subroutine is presented in Figure A-1(mm) of this report. The fuselage coordinate system is shown in Figure 5 in Volume II. The store coordinate system is shown in the following sketch.



The coordinates of the field point are given as formal parameters in the appropriate body coordinate system. The subroutine first transforms these coordinates into the VELCAL system by changing the sign of X and Z, and then into the polar coordinates XFIELD, RFIELD, and THETA.

The major part of the program consists of a DO loop within which the axial, radial, and tangential velocities due to the N sources and doublets are calculated and summed. A test is made to determine whether the field point is ahead of the Mach cone from the Ith source origin, TX(I). If so, all remaining perturbation velocities are equal to zero and no further calculations are performed within the loop. At the end of the subroutine, these velocities in the VELCAL system are resolved back into the body coordinate system.

The variables in the subroutine argument list are:

T	array containing the source strengths
TC	array containing the doublet strengths
TX	array containing the x locations of the origins of the singularities; positive, measured aft from tip of nose
N	number of line sources and doublets
XP	x coordinate of field point in body system
Y	y coordinate of field point in body system
ZP	z coordinate of field point in body system
U1	u/V_∞ perturbation velocity at field point; body system
V1	v/V_∞ perturbation velocity at field point; body system
W1	w/V_∞ perturbation velocity at field point; body system
BODYL	body x-station at which base singularities originate, feet
SUMK	strength of source originating at body base
SUMKD	strength of doublet originating at body base

Called by
DPRHS

A-49 Subroutine VELCMP

Subroutine VELCMP organizes and calls for the calculation of the aerodynamic influence coefficient matrices for the body source panels. This routine optionally reads the Mach number, angle of attack, and angle of roll. It initializes all Mach number parameters, rewinds any external files, and allocates temporary storage locations in blank common to hold blocks of influence coefficients. VELCMP performs the loop over the number of body segments calling BODVEL to compute the influence coefficients for the panels within

a segment on all other control points. A listing of this subroutine is presented in Figure A-1(nn) of this report.

The parameter in the argument list is:

IREAD option index whether to read the Mach number and
 angle of attack
 IREAD=0, read XMACH,ALPHAC,PHIR
 IREAD=1, no input read; parameters must be in
 common

Subroutine references

BODVEL, IOREAD, IOWRIT

Called by

WDYBDY, STORIO

A-50 Subroutine VELO1

Subroutine VELO1 calculates the aerodynamic influence functions of a semi-infinite triangle associated with a constant u -velocity panel, as described in Section II-2.1 of Appendix II of Reference 1. The influence functions relate the panel singularity strength to the perturbation velocities induced by the triangle at a given point. They occur as the coefficients of $1/\pi(u_+/V_\infty)$ in Equations (II-4) and (II-12) of Reference 1. A listing of the subroutine is presented in Figure A-1(nn), and a flow chart in Figure A-15 of this report. The coordinate system used by the subroutine is shown in Figure 3 of Reference 1.

At the beginning of the subroutine the logical variable FELT is initialized to TRUE and a test is performed to determine if the field point is located ahead of the influencing triangle ($X \leq 0$).

If so, the influence functions U,V,W are set to zero, FELT is set to FALSE, and control is returned to the calling program.

Next, the variable PYPNL is tested and, if the triangle is on the pylon, a transformation is performed which rotates the triangle into the VELO1 x,y plane. After the calculation of the logical variable INSIDE and other frequently used quantities, the remainder of the subroutine consists of four major sections in which the influence function terms, F1, F2, F4, F5, and F7, are calculated. Each section corresponds to a condition of the slope, EML, of the leading edge associated with the semi-infinite triangle. The subroutine requires that $EML \geq 0$ and this is accounted for in the VELO1 calling programs. The four leading-edge conditions are described fully, with accompanying sketches in Section II-2.1 of Reference 1. All equation numbers mentioned in the following paragraphs are from Section II-2.1 of Reference 1.

The first section of the subroutine corresponds to a subsonic leading edge, $BTSQ < EMLSQ$. Equation (II-5) is used if the point is inside the Mach cone from the origin, $INSIDE=TRUE$. If not, U,V, and W are set to zero. In this section as in the remaining ones, discontinuities in some of the equations may occur for certain field point locations. In such cases the affected influence function is set to zero. The quantities YYEDGE and TLRNC, as well as Y and Z, are used to test the singularity locations.

If $BTSQ=EMLSQ$, the leading edge is a sonic leading edge. The equations used are the same as for the subsonic case except for the function F2, which is given by Equation (II-7). If the point lies outside the Mach cone from the origin, the influence functions equal zero.

The third section of the subroutine is used if the triangle leading edge is supersonic, $BTSQ > EMLSQ$. Equations (II-5) and (II-9) calculate the terms of the influence functions if $INSIDE=TRUE$. If not, a second test is performed and Equation (II-11) is used if the point is inside the Mach cone whose origin is on the leading edge at the field point y location, otherwise the functions U,V,W are set to zero.

The fourth section of the subroutine is executed if the leading edge is unswept, $EML=0$. For this special case the perturbation velocity equations are given by (II-12). If $INSIDE=TRUE$, the influence function terms are given by (II-5) and (II-13). Outside the Mach cone from the origin but inside the cone from the leading edge Equation (II-14) is used, otherwise, U,V,W are set to zero.

The last part of the subroutine calculates the functions U,V,W from the component terms, in the case of a leading edge with positive sweep, using Equation (II-4). If the triangle is located on the pylon, V and W are rotated back into the pylon u -velocity panel coordinate system.

Called by

VELBD1, VELPP1, VELWP1

A-51 Subroutine VELOT1

Subroutine VELOT1 calculates the aerodynamic influence functions of a semi-infinite triangle associated with wing or pylon thickness panel, as described in Section II-2.2 of Appendix II of Reference 1. The influence functions relate the panel source strength to the perturbation velocities induced by the triangle at a given point. They occur as the coefficients of $1/\pi(\tan \theta)$ in Equations (II-15) and (II-16) of Reference 1. A listing of the subroutine is presented in Figure A-1(pp) of this report. The

subroutine is very similar in logic to subroutine VELO1 which is described in detail in Section A-50 and represented by a flow chart in Figure A-15.

In subroutine VELOT1, three component terms, F_1 , F_2 , and F_5 , need to be calculated in order to determine the influence functions UTH , VTH , and WTH . Referring to Sections II-2.1 and II-2.2 of Reference 1, function F_1 , F_2 , and F_5 are specified in Equation (II-5) for the case of a subsonic leading edge, in Equations (II-5) and (II-7) for a sonic leading edge, and in Equations (II-5), (II-9), and (II-11) for a supersonic leading edge. For the special case of an unswept leading edge ($EML=0$), the general perturbation velocity equations are given by (II-16). If the given point lies inside the Mach cone from the origin of the triangle, function F_1 is given by Equation (II-13), function F_5 by Equation (II-5), and function F_2 by Equation (II-17). If the point lies outside the Mach cone from the origin but inside the Mach cone from the triangle leading edge at the field point y location, functions F_1 , F_2 , and F_5 are given by Equation (II-16). In all leading edge cases, the function F_1 , F_2 , and F_5 are singular for certain field point locations. When this occurs, the affected influence function is set to zero. All influence functions are set equal to zero if the point lies in the plane of the semi-infinite triangle ($ZTH=0$).

A table equating the algebraic and program notation for variables in common for subroutine VELOT1 is presented in Appendix B-2 of this report. Almost all of the notation used in subroutine VELOT1 is defined in this table. One should note that the influence functions, U, V, W and the point coordinates, YS, ZS , in VELO1 are named UTH, VTH, WTH, YTH , and ZTH , respectively, in subroutine VELOT1.

Called by

VELOT1, VELPT1

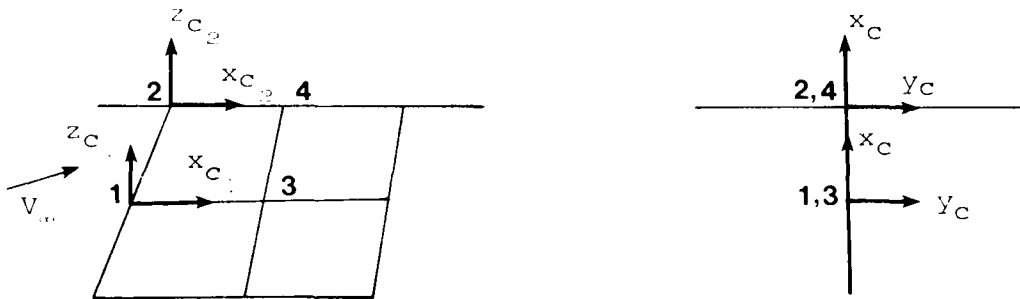
A-5. Subroutine VELPP1

Subroutine VELPP1 calculates the single panel influence coefficients which form the coefficients of $1/\pi(u_+/v_+)$ in Equation (12) of Reference 1. A listing of the subroutine is presented in Figure A-1(qq) and a flow chart in Figure A-16. The quantities XX, YY, ZZ in the subroutine argument list are the x,y,z coordinates in the wing coordinate system. The wing coordinate system is shown in Figure 7 of Volume II.

At the beginning of the subroutine, the logical variable PYPNL is set equal to TRUE, indicating to subroutine VELO1 that calculations are to be performed for a pylon panel. The quantities YDIR and YIMG are calculated and the velocity totals, UP, VP, WP, are initialized to zero. In the remainder of the subroutine the influence functions for the four corners of the panel are calculated and superposed. The superposition scheme is described in Section 3.3.4 of Reference 3 and that reference should be consulted for further details. The corner numbering convention for pylon panels associates corners one and two with the leading edge left and right corners, respectively; corners three and four with the trailing edge left and right corners, respectively. The left corners are those farther from the pylon root chord.

At the beginning of the calculation the influence function totals are initialized to zero and the leading-edge slope, EM1, and trailing-edge slope, EM2, are defined. Next, a test of the sign of EM1 is performed and two distinct transformation and superposition procedures are followed depending on the results of this test, as the flow chart indicates. In each procedure a test is

performed first to determine if the field point lies ahead of the most forward leading-edge corner; if so, all calculations for the i th panel are skipped. If the point is not ahead of the leading edge, the point is located relative to corner one in a corner coordinate system which is illustrated in the sketch below. Each panel corner has an associated coordinate system.



For a panel with swept back leading edge, $EM1 \geq 0$ the superposition scheme is the same as for a wing panel with positive sweep (see Figure 4, Reference 1). The field point z coordinate is reversed and subroutine VEL01 is called to calculate the influence of corner one on the image of the point with respect to the x, y plane. The sign of W is then reversed. The functions U, V, W are resolved back into the wing system and superposed. If the panel leading edge is swept forward, superposition is the same as for wing panels with negative sweep. The sign of $EM1$ is reversed and subroutine VEL01 returns U, V, W which are resolved into the wing system and superposed. It should be noted that the subroutine code combines superposition and transformation steps and that the final sign changes of U and W are made at the end.

The next calculations are omitted if the pylon is located under the fuselage centerline. Otherwise, the influence of the mirror image of corner one with respect to the vertical plane of symmetry

is calculated. This is accomplished by the equivalent method of calculating the direct influence of corner one on the image of the field point and then reversing the sign of V .

Corner one calculations are repeated in a similar manner for corners two, three, and four, but only corner one is described in detail in the flow chart. After superposition of the four corner influence functions for the panel is completed the influence coefficients for the i th pylon panel and the given control point are returned by the subroutine.

Subroutine references

VEL01

Called by

DPCOEF

A-53 Subroutine VELPT1

Subroutine VELPT1 calculates perturbation velocities at a field point due to the pylon thickness distribution according to method described in Section 3.3 of Reference 4. The program logic is very similar to that of subroutine VELPP1 which calculates velocities induced by the pylon constant u -velocity panels. Subroutine VELPP1 has been described in detail in Section A-52 and is represented by a flow chart in Figure A-16 of this report. Only those details, therefore, in which subroutine VELPT1 differs from subroutine VELPP1 are included in this description. A listing of the subroutine is presented in Figure A-1(ss). The quantities in the subroutine argument list are the x, y, z coordinates of the field point in the wing coordinate system.

The coordinates of the field point are given as formal parameters in the wing coordinate system. The point is located relative to each of the four panel corners using the same transformation scheme as in VELPPl. However, the corner coordinate arrays which define the pylon thickness panels and which have been previously calculated by subroutine THKLYT (see Section A-45) are used in the transformations. Subroutine VELOT1 is called to calculate the corner influence functions, U,V,W, which are then superposed in the same manner as in VELPPl.

The subroutine calculates perturbation velocities only. The influence coefficients are multiplied by DZDX(I) to obtain perturbation velocities induced by the Ith panel at the given point. These velocities are calculated and summed for all pylon thickness panels.

Subroutine references

VELOT1

Called by

DPRHS

A-54 Subroutine VELWP1

Subroutine VELWP1 calculates the influence coefficients at a specified control point due to a wing constant u-velocity panel. The influence coefficients occur in Equation (27) of Reference 3 as the coefficients of $(1/\pi)(u_+/V_\infty)$. A listing of the subroutine is presented in Figure A-1(tt), and a flow chart in Figure A-17. The quantities in the subroutine argument list are the x,y,z coordinates of the field point in the wing coordinate system. The wing coordinate system is shown in Figure 7 of Volume II.

At the beginning of the subroutine, the logical variable PYPNL is set equal to FALSE indicating to subroutine VELO1 that calculations are for a wing rather than a pylon panel. The influence function totals, TU, TV, TW, are initialized to zero. The leading edge slope, EM1, and the trailing edge slope, EM2, as well as the dihedral angle sine and cosine, are defined. The remainder of the subroutine consists of the calculation and superposition of the influence functions for the four corners of the influencing panel. The superposition scheme is described in Section 3.3.4 of Reference 1 and that reference should be consulted for further details. The corner numbering convention for wing panels is shown in Figure 4 of Reference 1.

Two distinct transformation and superposition procedures are followed depending on the sign of EM1, for corners one and two, and EM2, for corners three and four. In each procedure the point is first located relative to corner one in the coordinate system associated with subroutine VELO1, illustrated in Figures 3 and 4 of Reference 1. Dihedral effects, if nonzero, are included in the coordinate transformations. Subroutine VELO1 is called to calculate the corner influence functions, U,V,W, which are resolved back into the wing system and superposed. Superposition and transformation steps are combined in the code and the final sign changes of U and W are made at the end of the subroutine. Next, in each procedure, the influence of the image of corner one with respect to the aircraft vertical plane of symmetry is calculated. This is accomplished if $EM1 < 0$ by the equivalent method of calculating the direct influence of corner one on the field point image and then reversing the sign of V.

Corner one calculations are repeated in a similar manner for corners two, three, and four, but only corner one is detailed in the flow chart.

Subroutine references

VELO1

Called by

DPCOEF

A-55 Subroutine VELWT1

Subroutine VELWT1 calculates perturbation velocities at a given field point due to the wing thickness distribution, according to methods described in Section 3.3 of Reference 3. The program logic is very similar to that of subroutine VELWP1, which calculates influence functions for the wing constant u-velocity panels. Subroutine VELWP1 has been described in detail in Section A-54 and is represented by a flow chart in Figure A-17 of this report. Only those details, therefore, in which subroutine VELWT1 differs from subroutine VELWP1 are included in this description. A listing of the subroutine is presented in Figure A-1(wv). The quantities in the subroutine argument list are the x,y,z coordinates of the field point in the wing coordinate system.

The coordinates of the field point are given as formal parameters in the wing coordinate system. The point is located relative to each of the four corners of the trapezoidal shaped thickness panels using the same transformation schemes as in VELWP1. However, the corner coordinate arrays which define the wing thickness panels and which have been previously calculated by subroutine THKLYT (see Section A-45) are used in the transformations. Subroutine VELOT1 is called to calculate the corner influence functions, U,V,W, which are then superposed in the same manner as in VELWP1.

Finally, the subroutine calculates perturbation velocities rather than single panel influence coefficients. Thus, after

the calculation of the influence coefficients for the Ith panel is completed, the influence coefficients are multiplied by DZDX(I) to obtain the perturbation velocities induced by the Ith panel at the given field point. These velocities are calculated and summed for all wing thickness panels.

Subroutine references

VELOT1

Called by

DPRHS

A-56 Subroutine WDYBDY

Subroutine WDYBDY reads and prints the noncircular fuselage data and organizes the calling sequence for the body panel layout, the computation of the source strengths, and the generation of the nonlinear shock shape. A listing of the routine is presented in Figure A-1(zz) of this report.

WDYBDY is used to generate the required solutions for the noncircular fuselage. It first reads and prints the basic length, width, nose shock angle, and interference shell length and number of panels. The noncircular fuselage geometry is read and panels laid out in a call to GEOM. The panel cross section data to be used for the fuselage interference shell is saved by YZBIP. The influence coefficient matrices and the solution for the shock strength are generated in calls to VELCMP and SOLVE. The nonlinear shock shape is generated in a call to BSHOCK and all data to be passed to Program II saved on TAPE10 by FRSTRT.

Subroutine references

BSHOCK, FRSTRT, GEOM, INLSHK, SOLVE, VELCMP, YZBIP

Called by
LDCALC

A-57 Subroutine WITHIN

Subroutine WITHIN reads in the wing thickness data, input items 40, 41 and 42. A listing of the subroutine is presented in Figure A-1(aaa) of this report.

The number of panels in a chordwise row, NCWS, and the number of chordwise rows, MSWS, are first read in along with an index, NUNIS, which indicates whether the thickness distribution is similar at all spanwise stations. The subroutine then reads input item 41. Next, if NUNIS=1, the values of $\tan \theta$ are read in for the first chordwise row of panels and then the values of $\tan \theta$ for the other rows are set equal to those of the first row. If the thickness distribution is not similar, NUNIP=0, the values of $\tan \theta$ for all rows are read in.

After the thickness slopes are read in, an input error check is performed. If any of the $\tan \theta$ values is zero or negative at the wing leading edge, an error message is printed (see Section 3.5, Volume II) and the program halts.

Called by
LCALC

A-58 Subroutine WLYOUT

Subroutine WLYOUT calculates quantities which characterize the constant u-velocity panels on the wing. An example of a wing trapezoidal panel is shown in Figure 2 of Reference 1. Similar routines PLYOUT and BLYOUT calculate these quantities for the pylon and fuselage panels, respectively. The arrangement

of variables in any single coordinate array is wing panels first, pylon panels second, and fuselage panels last. All coordinates are in the wing coordinate system which is shown in Figure 7 of Volume II. A listing of the subroutine is presented in Figure A-1(aaa), and a flow chart in Figure A-18 of this report.

As indicated by the flow chart, the first part of the subroutine tests whether the wing leading-edge and trailing-edge sweep angles are constant at all spanwise Y-stations. If breaks in sweep occur, the indicator LVSWP is set equal to one; otherwise, LVSWP=0 and the quantity SLPDIF, the difference between leading-edge and trailing-edge slopes for a chordwise row, is computed outside the main DO loop.

After initializing the quantities CSIDEP, ZLER, and WLEX, the remainder of the subroutine consists of a double DO loop. The outer loop index, I, controls the chordwise row; the inner loop index, K, specifies the panel location in the Ith row. Within the inner loop, the leading-edge and trailing-edge slopes, the sine and cosine of the dihedral angle, the corner coordinates, and the control point coordinates are calculated and stored for each panel. The convention used in numbering the NPANLS wing constant u-velocity panels is the same as that used for the wing thickness panels. Section A-45 should be referred to for details. In the subroutine notation, the right-hand side of the panel is the one closer to the root-chord.

Called by
LDCALC

A-59 Subroutine WRFILE

Subroutine WRFILE writes the data set on TAPE12 which contains all the information required to continue the supersonic store

separation computations in Program II. A listing of the routine is presented in Figure A-1(bbb) of this report.

WRFILE writes all the data required for Program II unformatted on TAPE12. The data includes the list of headings, control indices, various constants, u-velocity data, thickness panel data, fuselage geometry and strength data, rack data, pylon data, and data for multiple stores. When saving information required for the noncircular fuselage or elliptic stores, the appropriate arrays are transferred from TAPE10 to TAPE12 using routine FRSTRT.

Subroutine references

FRSTRT

Called by

LDCALC

A-60 Subroutine YZBIP

Subroutine YZBIP is used to organize the scan of the source panel geometry to define the cross section data for the non-circular fuselage interference shell. YZBIP performs the loop over the number of body segments in organizing the data for a scan of the axial geometry. The scan of panel geometries within a segment are performed in a call to YZBIP2. A listing of this subroutine is presented in Figure A-1(ccc) of this report.

Subroutine references

YZBIP

Called by

WDYBDY

A-61 Subroutine YZBIP2

Subroutine YZBIP2 scans the source panel geometry of a single body segment and performs the interpolation in the data to define the y-z values of the section to be used by BLYOT2 to define the body interference shell. The routine scans the arrays of axial stations to find the two sections which bound the input station, XBIP (item 15). A linear interpolation between the Y-Z values of the two sections is then performed. This table of Y-Z values is used by BYLOT2 to specify the Y-Z values of the fuselage interference shell as close to the source panel geometry as possible. A listing of this routine is presented in Figure A-1(ccc) of this report.

The descriptions of the parameters in the argument list follow:

XB	array of axial stations of section data of segment
YB,ZB	arrays of Y-Z coordinates of panel corners
KRAD	number of corners in the polar direction about the body
NFUSOR	number of axial stations in segment

Called by
YZBIP

Figure A-1.- Listing of Program I

(Pages 84 through 138)

```

PROGRAM LOCALC(INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT,TAP12
* TAP17,TAP18,TAP19,TAP20,TAP21)
C
C PROGRAM TO CALCULATE SIX-DEGREE-OF-FREEDOM STORE TRAJECTORIES
C AT SUPERSONIC SPEEDS
C
C THIS IS PROGRAM 1
C
C THIS PROGRAM LAYS OUT THE PANELS REPRESENTING THE PARENT AIRCRAFT,ALPHA
C CALCULATES BODY SOURCE AND DOUBLE STRENGTHS, AND THE CONSTANT ALPHA
C U VELOCITY PANEL STRENGTHS.
C
C ALL QUANTITIES READ IN BY THIS PROGRAM OR CALCULATED BY THIS
C PROGRAM ARE REQUIRED BY THE TRAJECTORY PROGRAM,
C PROGRAM 2, ARE WRITTEN OUT ON TAPE 12.
C
C THE TRAJECTORY CALCULATION PROGRAM READS THIS DATA SET IN.
C
C LOGICAL CENTER
C
C DIMENSION STATEMENTS
C
C DIMENSION HEAD(20),FVNI(200,20)
C
C COMMON STATEMENTS
C
C COMMON /BPGEOM/ SWIZ(200),CST2(200),ZLC(200),ZRC(200),TMT(200),
C SANG
C COMMON /CAMBER/ ALPHA(200)
C COMMON /CONFIG/ NFU,NPY,NSTRS,LVSWP,NRACK
C COMMON /CONST/ PI,P12,DTPR,RTD,FOURPI
C COMMON /EVAL/ VET(200),VEL(200),WEI(200),CIR(200)
C COMMON /FLOW/ ALFAC,CAMP,FACH,MO,VINF,BETA,BETASO,FACHSO
C COMMON /FSEGM/ FMAA,SSPAN,IF,FLTHC,LEDTOT,TP(200)
C COMMON /INDEX/ MCP,MSW,MSP,NPANELS,NCRB,NBCR1,NBCR2,NBO,NBIP,NBPL
C /MCP,MSP,NP,N2,NBP,NPTOT
C COMMON /PTGEOM/ Z1(20),APLE,VPL,CRP,NP,PSIPLE(20),IP,
C SLE,PSLPDF,CENTER,ZPL,LVSPP
C COMMON /RAGEOM/ RMAX,RLTHC,XARC,YRO,ZARO,NRPOL,RFEND(7),
C RCOEF(7),XRO,YRO,ZRO,RIBCR,SRIBCR,CRIBCR
C COMMON /SHPOAT/ NPOLY,FXEND(7),FCOEF(7,7)
C COMMON /STGEOM/ SRMAX(7),SLTHC(7),RMSOC(7),YMSO(7),ZMSO(7),
C NSPOLY(7),XEND(7),SCOE(7,7),XCOEF(7,7),YMSO(7),ZMSO(7),
C SIBCR(7),NSTR(7),SSIBCR(7),CSIBCR(7),SPHRR(7),NSHAP(7)
C COMMON /THKDAT/ NCPS,NCPS,MS,MPS,MSPS,NTHP,ARFT(400),ARBT(400),LOCA
C 1 XFLT(400),XLBST(400),YRCT(400),YLCFT(400),ZPCT(400),ZLCFT(400),
C 2 THETAL(400),THETPL(200),SLETT(400),SLETT(400),OZDA(400),
C 3 YS12(400),PSHSLT(20),PSHSTE(20),PHIS12(400),PSPSLE(20),
C 4 PSOSTE(20),SNPHS(400),CSPMS(400)
C COMMON /VELARG/ X,DUMY,DUMZ,U,V,W,EM,TLRNC,TIPY,PYPMNL
C COMMON /VUEOM/ ARBOC,ZBWO,CRW,SLPHLE,SLPHTE,PSIMLE(20),
C 1 PSIMTE(20),Y12(20),PHI(20),ZDTHED,WICH
C COMMON /APGEOM/ ARFT(200),ARBT(200),ALF(200),ALB(200),YRC(200),
C 1 YLC(200),ZCPT(200),ZCPT(200),ZCPT(200),ZCPT(200),ZCPT(200),
C 2 ZCPT(200),ZCPT(200)
C COMMON /EVALUANCE/ IFVNI(1),A1(1))
C
C FORMAT STATEMENTS
C
C 701 FORMAT(10I5)
C 702 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 703 FORMAT(20A1)
C 704 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 705 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 706 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 707 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 708 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 709 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 710 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 711 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 712 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 713 FORMAT(10I5,36X,51MSUPERSONIC SIX-DEGREE-OF-FREEDOM TRAJECTORY PROGLCA 660
C 1RAN//)
C 10 FUSELAGE NOSE/25X,ANR =F10.5,5M FEET/25X,ANR =F10.5,5M FEET LOCA 740
C

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Figure A-1(a)

Figure A-1(c)

AD-A099 331

NIELSEN ENGINEERING AND RESEARCH INC MOUNTAIN VIEW CA F/G 20/4
PREDICTION OF SUPERSONIC STORE SEPARATION CHARACTERISTICS INCLU--ETC(U)
NOV 80 J MULLEN, F K GOODWIN, M F DILLENIUS F33615-76-C-3077
UNCLASSIFIED NEAR-TR-210-VOL-3 AFWAL-TR-80-3032-VOL-3 NL

2 of 3

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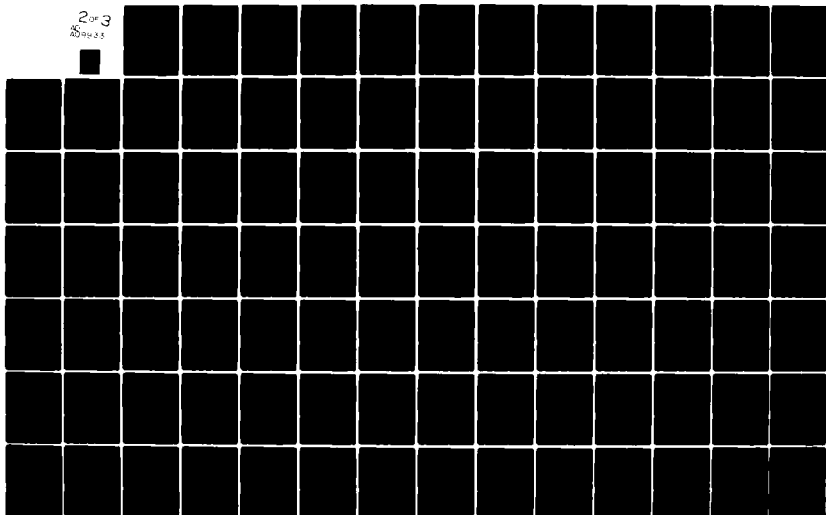


Figure A-1(h)

Figure A-1(i)

Figure A-1(j)

Figure A-1(k)


```

VEI(J)=VEI(J)+VP
WEI(J)=WEI(J)+WP
155 CONTINUE
C
C C CALCULATE RIGHT HAND SIDE
C C
C C -- BING BOUNDARY CONDITION --
C C
111 CONTINUE
DO 120 J=1,NPANELS
120 CIR(J)=(ALFACR*ALPHAL(J)+WICR)*CSPH(J)+VEI(J)+SUPH(J)-
1 (WEI(J)+ALPHAL(J)+WEI(J))*CSPH(J)
C
C C -- PYLON BOUNDARY CONDITION --
C C
IF (IMPY.EQ.0) GO TO 131
DO 130 J=NP1,N2
IF (CENTERT VEI(J)=0.
130 CIR(J)=WEI(J)
C
C C -- FUSELAGE INTERFERENCE PANEL BOUNDARY CONDITION --
C C
ONLY V NORMAL IS USED IN FUSELAGE BOUNDARY CONDITION
C
131 IF (IMPY.EQ.0) RETURN
DO 140 J=NP2,NPTOT
NB=J-N2
WB=WEI(J)*CST2(NB)-VEI(J)*SMT2(NB)
140 CIR(J)=WB
RETURN
END
C
SUBROUTINE FLOWEL (XFP,YFP,ZPT,SVN,LSKP,V,VW,NFLD,ID,16)
C
C ROUTINE TO COMPUTE U,V,W VELOCITY COMPONENTS AT THE FIELD POINTS
C XFP,YFP,ZPT. ALL FIELD POINTS HAVE THE SAME BETA EXCEPT THE
C DESIGNATED INLET PANELS. THEY USE MINIMUM OF BETA0 AND BTINLT
C
COMMON A(12000)
LOGICAL LSKP(NFLD)
DIMENSION XFP(NFLD),YFP(NFLD),ZPT(NFLD),U(NFLD),V(NFLD),W(NFLD)
*SVN(10),ID(130)
DATA IDLS17/-1/
C
C INITIALIZE VELOCITY COMPONENTS TO ZERO.
C
DO 100 I=1,NFLD
LSKP(I)=-.FALSE.
U(I)=0.
V(I)=0.
W(I)=0.
C
C DEFINE INDEX OF FIRST LOCATION IN A-ARRAY OF PANEL
C GEOMETRY AND STRENGTH
100 I=ID(73)
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Figure A-1(n)

Figure A-1(r)

Figure A-1(w)


```

3 READ(5,702) (THETPL(JP),JP=JNP,MN)
RETURN
5 READ(5,702) (THETPL(JP),JP=1,NCP5)
DO 6 J=2,NCP5
  JPL(J)=1+NCP5
DO 6 K=1,NCP5
  KKEJJK
6 THETPL(KK)=THETPL(K)
RETURN
END

SUBROUTINE RACK10
C
C SURROUTINE TO INPUT AND OUTPUT RACK DATA
C LINE SOURCE AND DOUBLET DISTRIBUTION ARE CALCULATED
C USING SUBROUTINE BODYEN
C
COMMON /BASES/ FRASE,FSUMK,FSUMKD,NBASE,MSUMK,MSUMKD,SHASE(7),
1 SHAP(7),JNP,MN
COMMON /RGEOM/ SNT(200),CST(200),ZLC(200),ZRC(200),FWT(200),
1 SANGW
COMMON /CONST/ PI,PI2,OTOR,RTOD,FOURPI
COMMON /FLOW/ AL,ACR,GMF,FMACH,PHO,VINF,BETA,BETASQ,FMCHSQ
COMMON /INDEX/ NCM,MSW,MSWP,NPANKS,NCWP,NBDCR1,NBDCR2,NBD,NBIP,MP,
1 NCP,NSP,NIP,N2,N2P,NPTOT
COMMON /PYGEO/ Z(20),XPLE,XPL,XCRP,HP,PS(PILE(20)),PS(PILE(20)),IP,
1 SLE,PSLDDF,CENTER,ZPL,LVSP
COMMON /RGEOM/ RMAX,PLTHC,ARHC,YRHO,ZRHO,NRPOLY,PREND(7),
1 MCFE(7),ZBHO,ZRHO,ZBRC,PIBCH,ZRIG,CRICR
COMMON /RSHOCK/ RASHN,RASHM(50),RQDS(100),NRSDR
COMMON /RBL/ RBL(100),RQDS(100),NRSDR
COMMON /RGEOM/ ZRHO,ZRHO,CM,SLP,PLE,SLP,PLE,PS(PILE(20)),
1 PS(PILE(20)),X(20),Y(20),Z(20),D(20),W(20),
1 COMMON /RGEOM/ ARF(200),ARF(200),ALB(200),YRC(200),
1 YLC(200),ACPT(200),YCPT(200),ZCPT(200),SMPLT(200),SMPLT(200),
2 SMPLT(200),CSPM(200)
COMMON /XSHOLD/ FASHLD,RASHLD,SXSHLD(7)
C
C FORMAT STATEMENTS
C
701 FORMAT(8F10.0)
702 FORMAT(11M10.1,15H RACK INPUT DATA)
703 FORMAT(11M10.1,15H RACK INPUT DATA)
704 FORMAT(11M10.1,15H RACK INPUT DATA)
705 FORMAT(11M10.1,15H RACK INPUT DATA)
706 FORMAT(123A.12,3X,7F10.5)
707 FORMAT(18X,51H COEFFICIENTS OF POLYNOMIALS DESCRIBING EACH SECTION/RACK 410
121X,7H SECTION/5X,2HC1,8X,2HC2,8X,2HC3,8X,2HC4,8X,2HC5,8X,2HC6,8X,
2HC7)
708 FORMAT(11X,101H RACK SHAPE AS CALCULATED FROM THE INPUT POLYNOMIALS,
1 ORIGIN OF SOURCES AND DOUBLETS REPRESENTING THE/20X,52H RACK 450
2 AND VALUES OF THE SOURCE AND DOUBLET CONSTANTS)
709 FORMAT(11X,21H RACK SHOCK WAVE SHAPE/8X,22H NOSE TIP SHOCK ANGLE
1=7.3-8M DEGREES)
C
C HEAD IN AND WRITE RACK GEOMETRY
C
READ (5,701) PLTHC,RRMAX,ZRNC,ZRM,RIC
WRITE(6,703) PLTHC,RRMAX,ZRNC,ZRM,RIC
C
C READ IN AND PRINT POLYNOMIALS DESCRIBING RACK SHAPE
C
READ (5,704) NRPOLY
READ (5,701) (REND(J),J=1,NRPOLY)
DO 1 J=1,NRPOLY

```

Figure A-1(cc)

Figure A-1(ff)


```

DO 37 J=1,N5
37 DZAL(1)=METAL(1)/PI
RETURN
END

SURROUTINE VELBD(J,X,Y,Z)
CALCULATES THE INFLUENCE COEFFICIENTS DUE TO A BODY INTERFERENCE
CONTROL POINT 3: - CONSTANT U VELOCITY PANEL
INFLUENCE COEFFICIENTS - P,VP,WP ARE RETURNED IN THE WING
REFERENCE FRAME
COMMON/MPGEOM/SMZ(200),CSZ(200),ZLC(200),ZRC(200),THT(200),
1 SANGW
COMMON/INDEX/NCB+MSB+NSP+NPML+NCB+MBOCH(1)+NBDC2+NB0+NHIP+WP,
1 NCP+NSP+NPML+NP2+NP2+NP2+NP2(200),ALH(200),YBC(200),
COMMON/MPGEOM/SMZ(200),CSZ(200),ZLC(200),ZRC(200),THT(200),
1 YLC(200),ZLC(200),YBC(200),ZRC(200),SMPL(200),SMPL(200),SMPL(200),
COMMON/VELBD/XY(200),Z(200),V(200),W(200),T(200),P(200),VP(200),WP(200)
LOGICAL PYPML,FELTA,FELTAI,FELTB,FELTB1,FELT
THERE ARE TWO COORDINATE SYSTEMS IN USE IN THIS SUBROUTINE --
SYSTEM 1 - WING COORDINATE SYSTEM
X,U POSITIVE FORWARD
Y,V POSITIVE DOWNRIGHT
Z,W POSITIVE DOWN
SYSTEM 2 - ORIGIN AT VERTICE OF INFLUENCING SEMI-INFINITE TRIANGLE
(X,UP POSITIVE BACK
Y,V POSITIVE COUNTERWISE LOOKING FORWARD, IN PLANE OF
INFLUENCING PANEL
Z,W POSITIVE OUTWARD NORMAL TO INFLUENCING PANEL
INFLUENCE COEFFICIENTS JP,VP,WP ARE IN SYSTEM 1
PYPML=.FALSE.
UP=0.0
VP=0.0
WP=0.0
XI=0.0
YI=0.0
ZI=0.0
E=0.0
I IS THE INDEX OF THE INFLUENCING PANEL
F=1
F=1
CSZ(200)
SMZ(200)
SMZ(200)
FELT=.FALSE.
T=0.0
T=0.0
IF(I)GE,ALF(1) GO TO 40
IF(I)TH(1),GT,90.,AND,TH(1),LE,180., GO TO 15
***** CORNER 1 *****
EQUATIONS FOR PANELS IN LOWER LEFT QUADRANT
X IS IN SYSTEM 2
X=RLF(1)-RI

```

Figure A-1(kk)

Figure A-1(aq)


```

C      CORNER 2 FOR EM1 .LT. 0
C
17 CONTINUE
  X=Z1-ZACT(I)
  Y=V1
  Z=Z1-ZACT(I)
  CALL VELOTT(FELTA)
  IF(.NOT.FELTB) GO TO 35
  TU=U-U
  TV=V-V
  TW=TW-W
  35 IF(CENTER) GO TO 40
  Y=YM
  CALL VELOTT(FELTB)
  IF(.NOT.FELTB) GO TO 40
  TU=U-U
  TV=V-V
  TW=TW-W
  GO TO 40
C
C      CORNER 4 FOR EM2 .LT. 0
C
21 CONTINUE
  X=X1-XACT(I)
  Y=Y1
  Z=Z1-ZACT(I)
  CALL VELOTT(FELTB)
  IF(.NOT.FELTB) GO TO 28
  TU=U-U
  TV=V-V
  TW=TW-W
  28 IF(CENTER) GO TO 40
  Y=YM
  CALL VELOTT(FELTB)
  IF(.NOT.FELTB) GO TO 40
  TU=U-U
  TV=V-V
  TW=TW-W
C
C      SIGN CHANGES NECESSARY TO ACCOMMODATE USE OF SUBROUTINE
C      VELOTT WITH DIFFERENT COORDINATE SYSTEM
C
40 CONTINUE
  U=U-U
  V=V-V
  W=W-W
C
C      CALCULATION OF PERTURBATION VELOCITIES
C
  UP=UP+U*QZ(I)
  VP=VP+V*QZ(I)
  WP=WP+W*QZ(I)
  100 CONTINUE
  RETURN
  END
C
SUBROUTINE VELMPL(X,Y,Z)
  VELM 10
  VELM 20
  VELM 30
  VELM 40
  VELM 50
  VELM 60
  VELM 70
  VELM 80
  VELM 90
  VELM 100
  VELM 110
  VELM 120
  VELM 130
  VELM 140
  VELM 150
  VELM 160
  VELM 170
  VELM 180
  VELM 190
  VELM 200
  THIS SUBROUTINE CALCULATES THE INFLUENCE COEFFICIENTS DUE TO A
  WING CONSTANT U VELOCITY PANEL AT THE CONTROL POINT OF ANOTHER
  CONSTANT U VELOCITY PANEL
  SUPERPOSITION OF A CORNER SOLUTIONS IS USED
  INFLUENCE COEFFICIENTS UP,VP,WP ARE RETURNED IN THE WING
  REFERENCE FRAME
  COMMON/BRIDGEOM/SMT(200),CS(200),ZLC(200),ZMC(200),TMT(200),SNGM(200)
  COMMON/ICVLP/UP,VP,WP,II,IF,DELTA(200)
  COMMON /WGFOM/WRWOC,ZRWOC,CHW,SLPWLE,SLPWTE,PSIWLE(200),PSIATE(200),
  1  /UM(200),PM(200),ZDI(200),ZDI*WLE,WLE
  COMMON /WPGCOM/XP(200),XOR(200),XLF(200),XLB(200),YMC(200),
  1  YLC(200),YCP(200),YCF(200),ZCMT(200),ZCMT*WLE(200),SWP(200),VELM 150
  2  SPM(200),CSPMT(200)
  COMMON /VELARG/ATV,ZV,U,V,W,EM,TLRMC,TLV,PTMPL
  LOGICAL PYMPL,FELT,FELTA,FELTB,FELTB*JOINED

```

Figure A-1(tt)

```

C STATEMENT FUNCTIONS FOR COORDINATE AND VELOCITY ROTATIONS
C
C ROTAT(A,B)=A*CSPH+B*SNPH
C ROTAT(A,B)=A*SNPH+B*CSPH
C ROTAT(A,B)=A*CSPH+B*SNPH
C ROTAT(A,B)=A*SNPH+B*CSPH
C
C PPHL=.FALSE.
C
C UP=0.0
C WP=0.0
C XI=XI
C YI=YI
C ZI=ZI
C
C I IS INDEX OF INFLUENCING PANEL
C
C I=1
C
C FELT=.FALSE.
C
C TU=0.0
C TM=0.0
C
C EM1=SUPPLE(I)
C EM2=SUPPLE(I)
C CSMH=CSPH(I)
C SNPH=SNPH(I)
C
C ***** CORNER 1 *****
C
C IF (EM) .LT. 0.01 GO TO 15
C
C CORNER 1 FOR EM1 .GE. 0 ---PANEL LEADING EDGE SWEEP BACK
C
C IF (X1-GE.XRF(I)) GO TO 40
C
C ICR=1
C
C X=X1*ALF(I)
C Y=Y1*YLC(I)
C Z=Z1*ZLC(I)
C
C ZVZ
C
C IF (ZDIHED) GO TO 80
C
C Y=ROTAC(Y,Z)
C Z=ROTBC(Y,Z)
C
C 60 CONTINUE
C
C CALL VELO(FELTA)
C
C IF (.NOT.FELTA) GO TO 50
C
C W=VW
C
C IF (ZDIHED) GO TO 62
C
C V=ROTAC(VW,W)
C W=ROTBC(VW,W)
C
C 62 CONTINUE
C
C TU=TV
C
C TM=TW
C
C FELT=.TRUE.
C
C Y=Y1*YLC(I)
C
C 50 IF (ZDIHED) GO TO 64
C
C V=ROTAC(Y,Z)
C Z=ROTBC(Y,Z)
C
C 64 CONTINUE
C
C CALL VELO(FELTA)
C
C IF (.NOT.FELTA) GO TO 10
C
C W=VW
C
C IF (ZDIHED) GO TO 66
C
C V=ROTAC(VW,W)
C W=ROTBC(VW,W)
C
C 66 CONTINUE
C
C TU=TV
C
C TM=TW
C
C ***** CORNER 2 *****
C
C IF (EM) .LT. 0.01 GO TO 15
C
C CORNER 2 FOR EM1 .GE. 0 ---PANEL LEADING EDGE SWEEP FORWARD
C
C 15 CONTINUE
C
C IF (X1-GE.XRF(I)) GO TO 40
C
C ICR=1
C
C X=X1*ALF(I)
C Y=Y1*YLC(I)
C Z=Z1*ZLC(I)
C
C ZVZ
C
C IF (ZDIHED) GO TO 80
C
C Y=ROTAC(Y,Z)
C Z=ROTBC(Y,Z)
C
C 80 CONTINUE
C
C CALL VELO(FELTB)
C
C IF (.NOT.FELTB) GO TO 12
C
C W=VW
C
C IF (ZDIHED) GO TO 82
C
C V=ROTAC(VW,W)
C W=ROTBC(VW,W)
C
C 82 CONTINUE
C
C TU=TV
C
C TM=TW
C
C ***** CORNER 2 *****
C
C CORNER 2 FOR EM1 .GE. 0
C
C 10 CONTINUE
C
C ICR=2
C
C X=X1*XRF(I)
C Y=Y1*YRC(I)
C Z=Z1*ZRC(I)
C
C ZVZ
C
C IF (ZDIHED) GO TO 80
C
C Y=ROTAC(Y,Z)
C Z=ROTBC(Y,Z)
C
C 80 CONTINUE
C
C CALL VELO(FELTB)
C
C IF (.NOT.FELTB) GO TO 12
C
C W=VW
C
C IF (ZDIHED) GO TO 82
C
C V=ROTAC(VW,W)
C W=ROTBC(VW,W)
C
C 82 CONTINUE
C
C TU=TV
C
C TM=TW
C

```

Figure A-1(uu)

Figure A-1 (ccc)

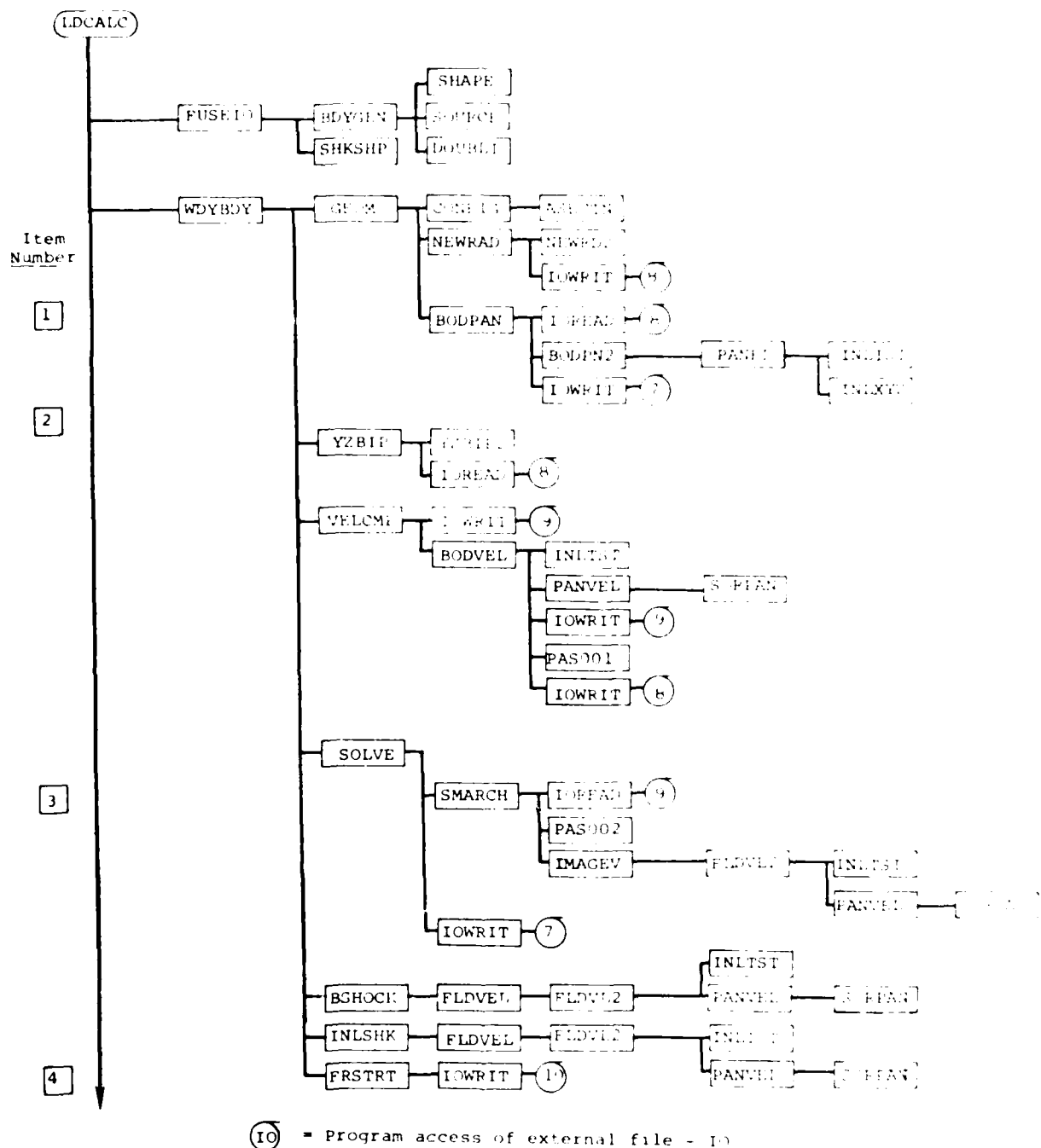


Figure A-2.- General flow chart of Subroutine Calls in Program 1.

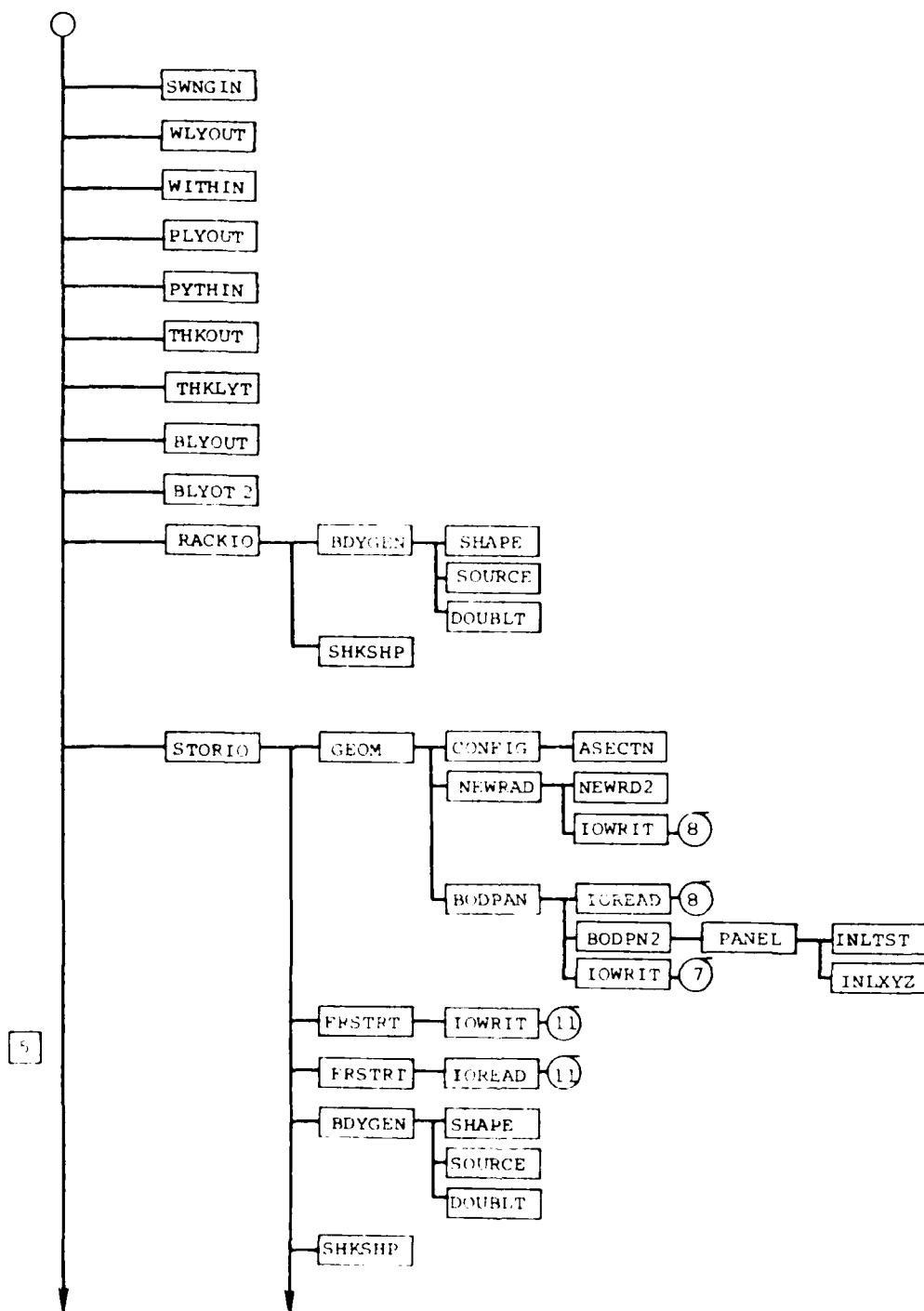


Figure A-2.- Continued.

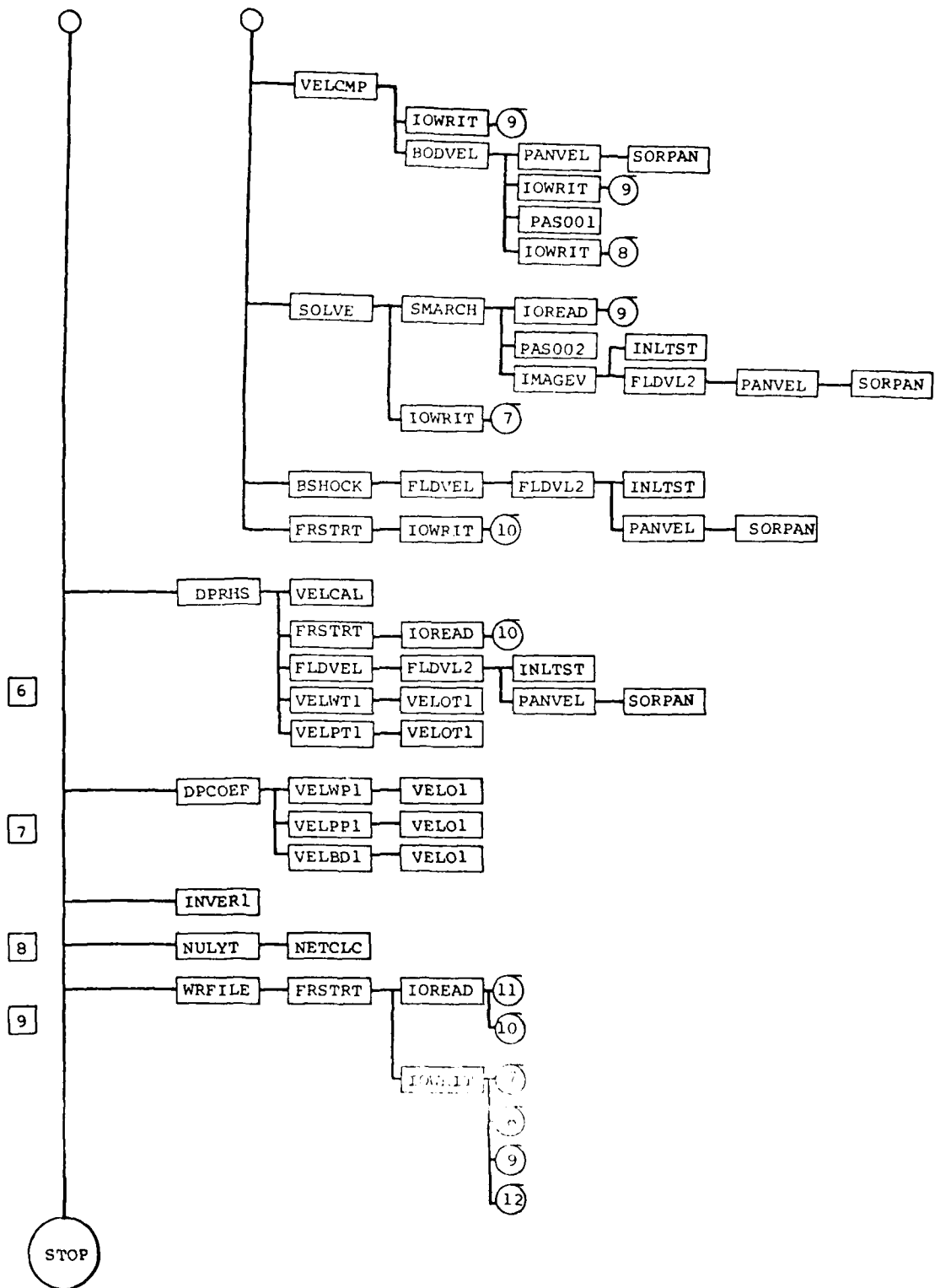
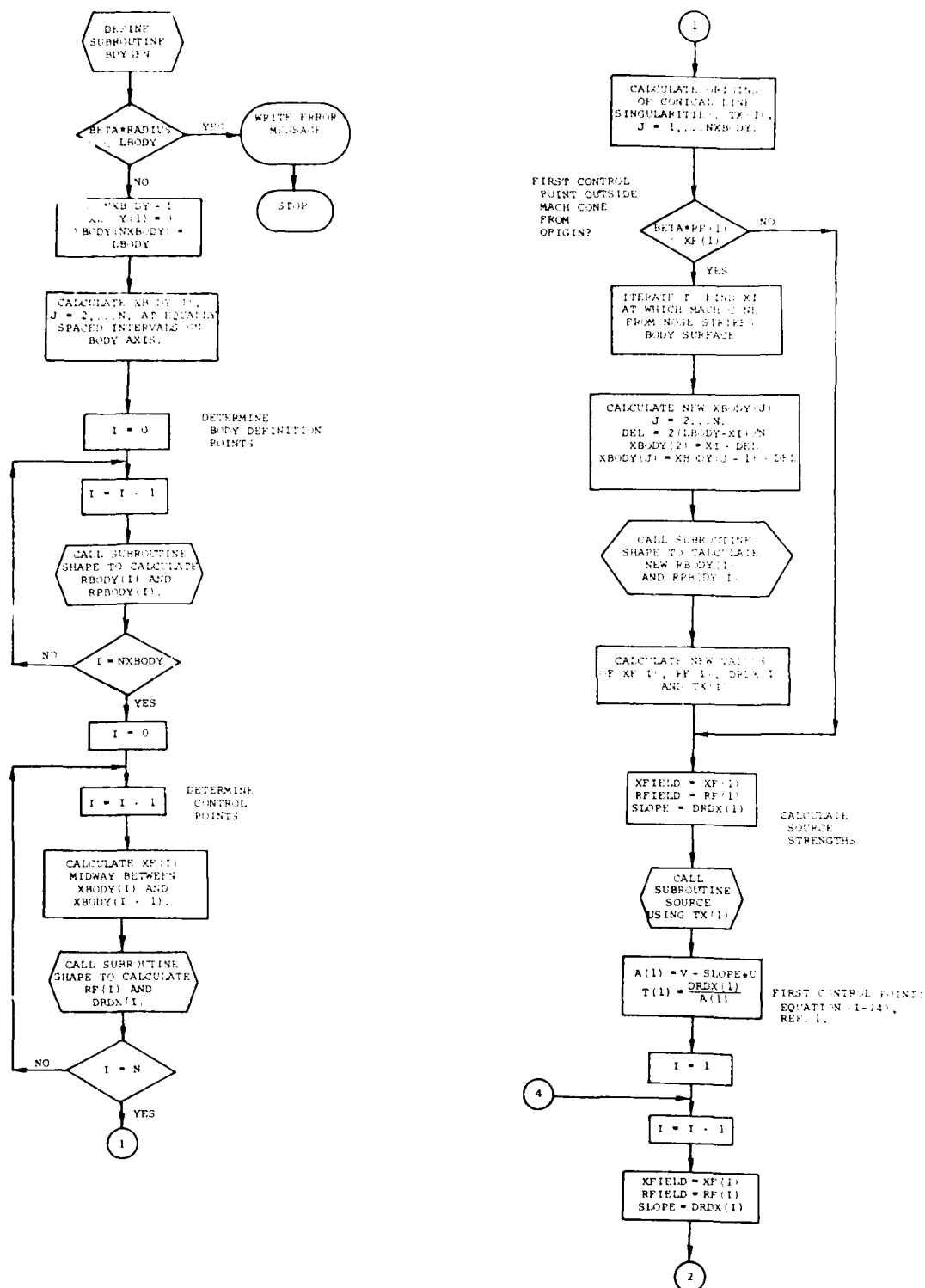
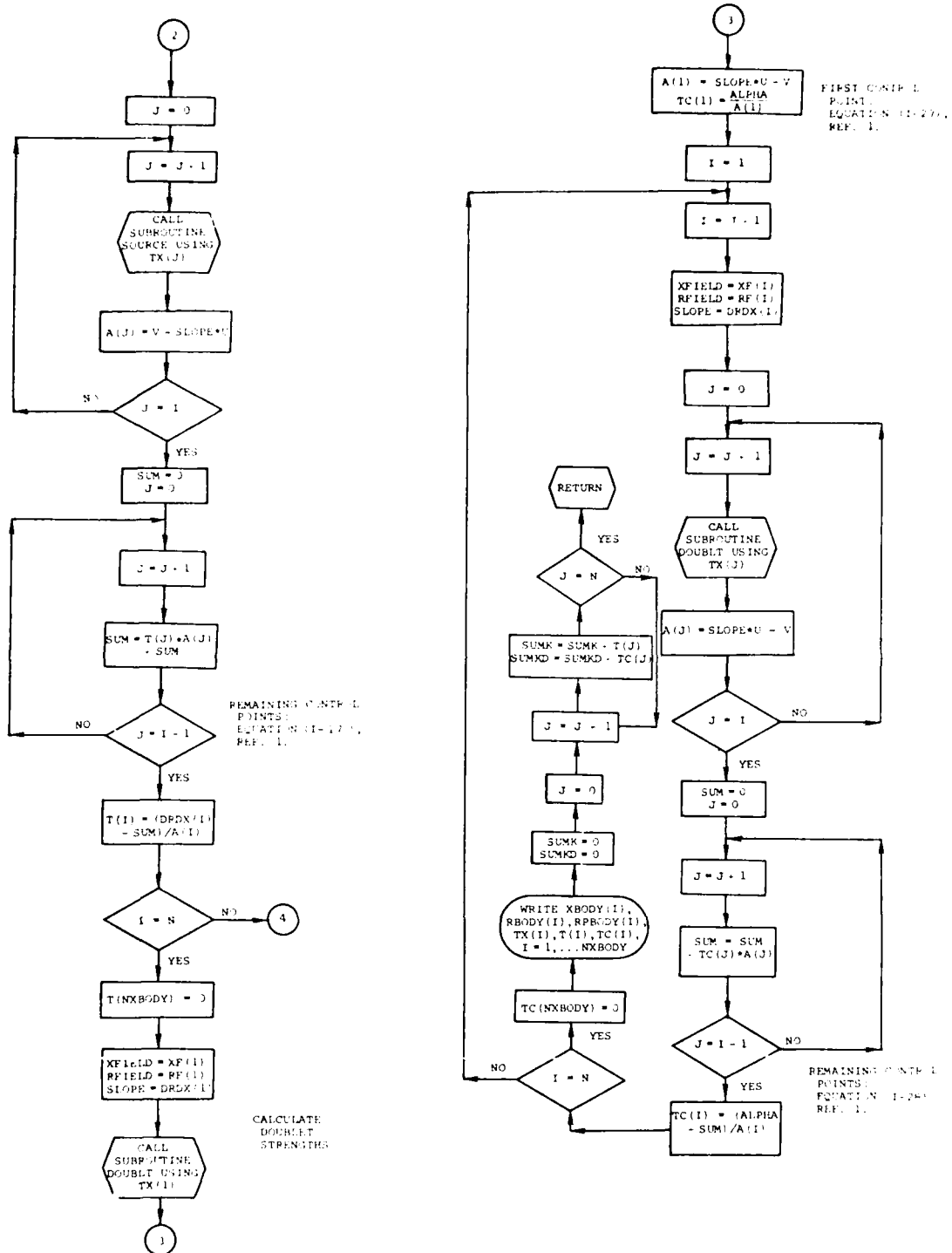


Figure A-2.- Concluded.



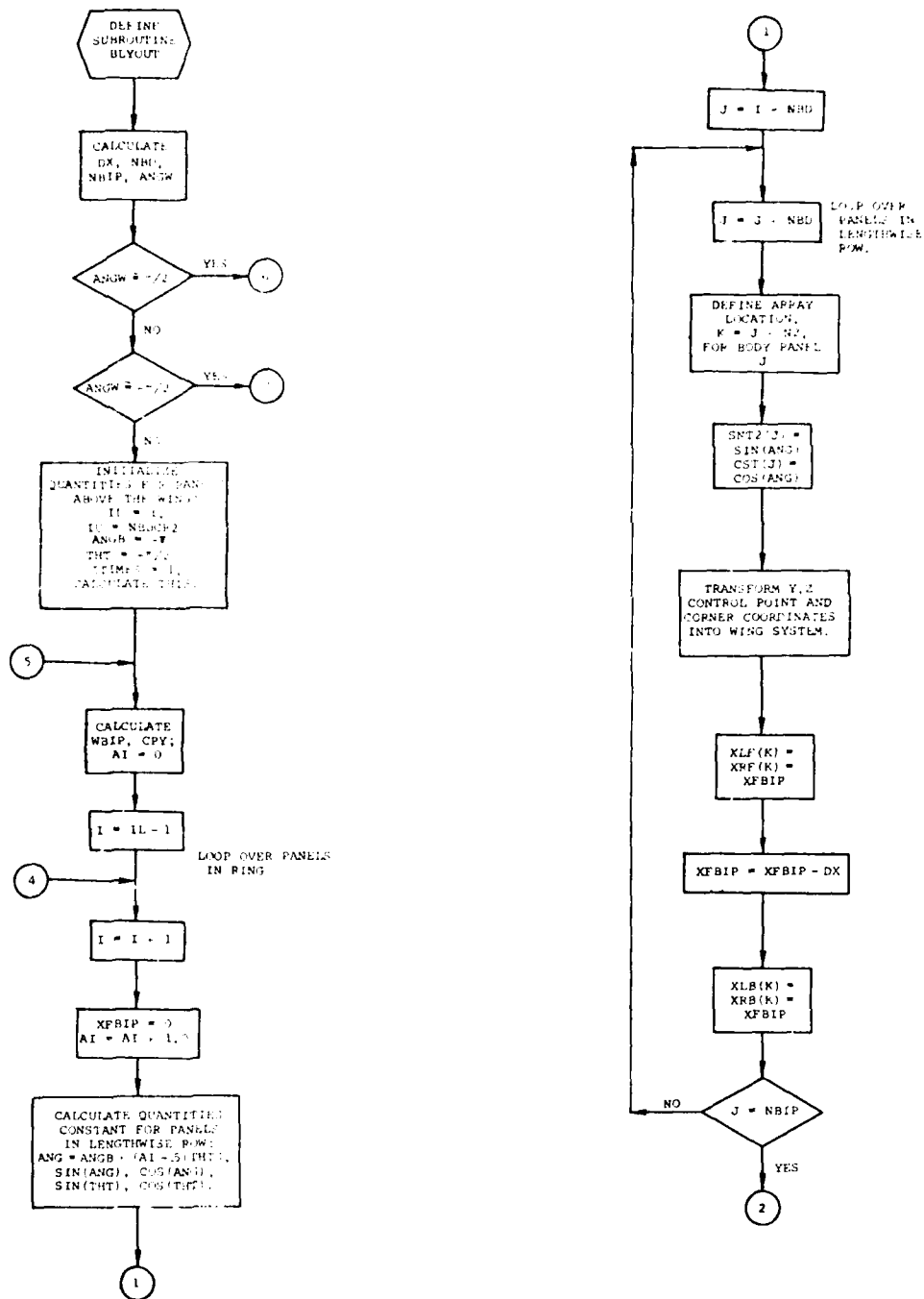
(a)

Figure A-3.- Flow chart of subroutine BDYGEN.



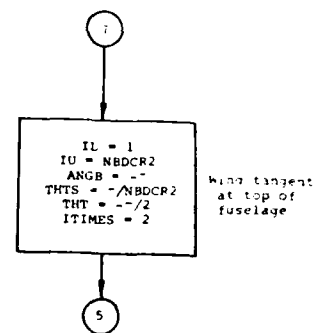
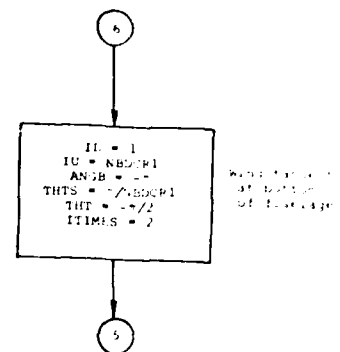
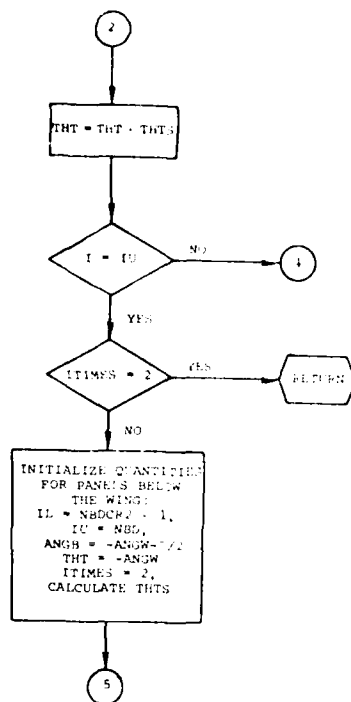
(b)

Figure A-3.- Concluded.



(a)

Figure A-4.- Flow chart of subroutine BLYOUT.



(b)
Figure A-4.- Concluded.

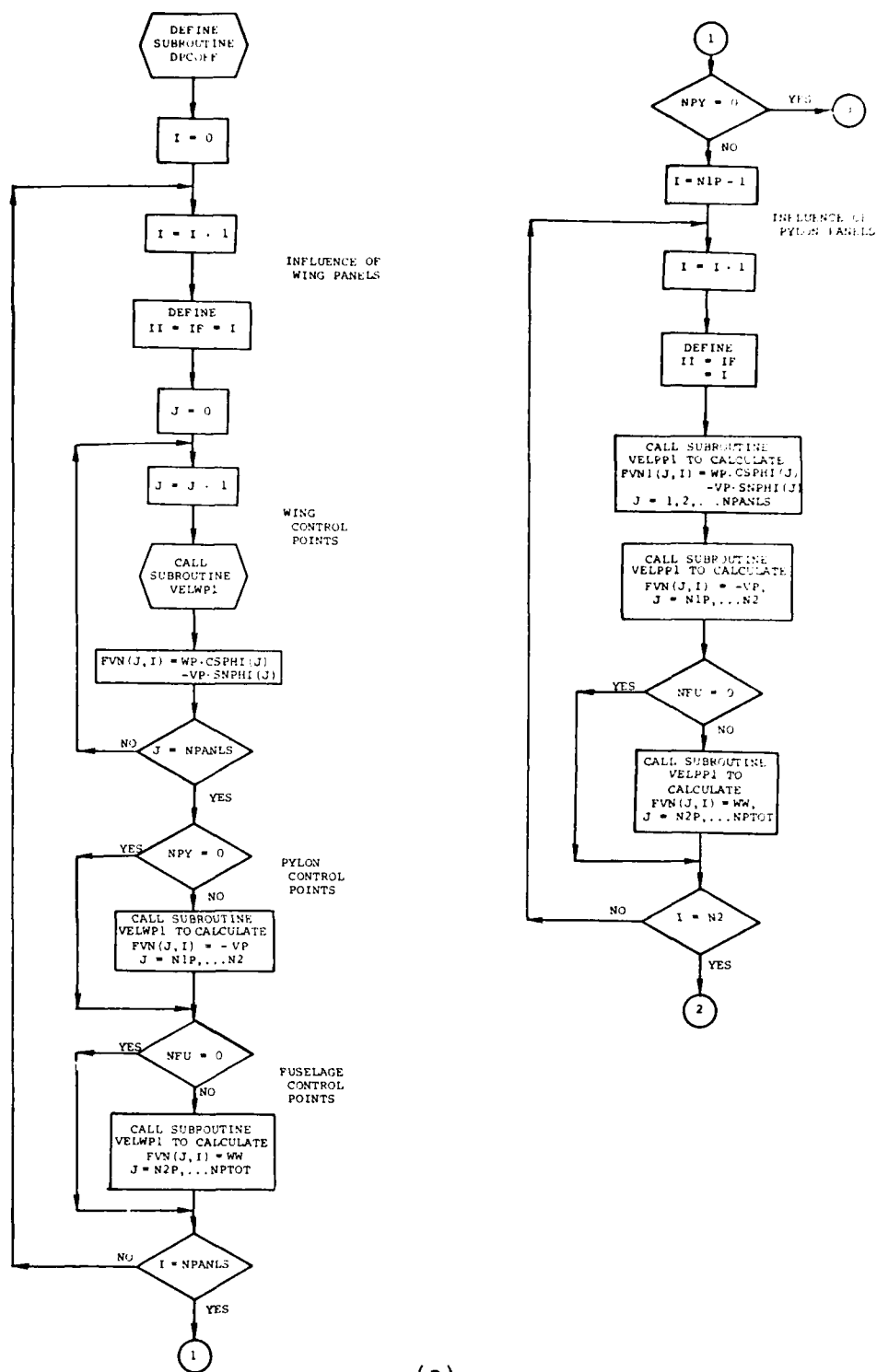
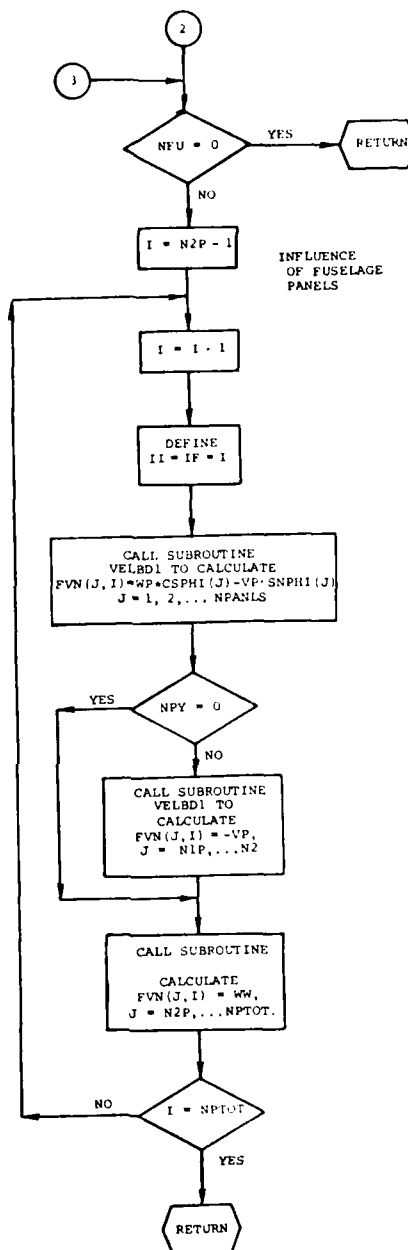


Figure A-5.- Flow chart of subroutine DPCOEF.



(b)

Figure A-5.- Concluded.

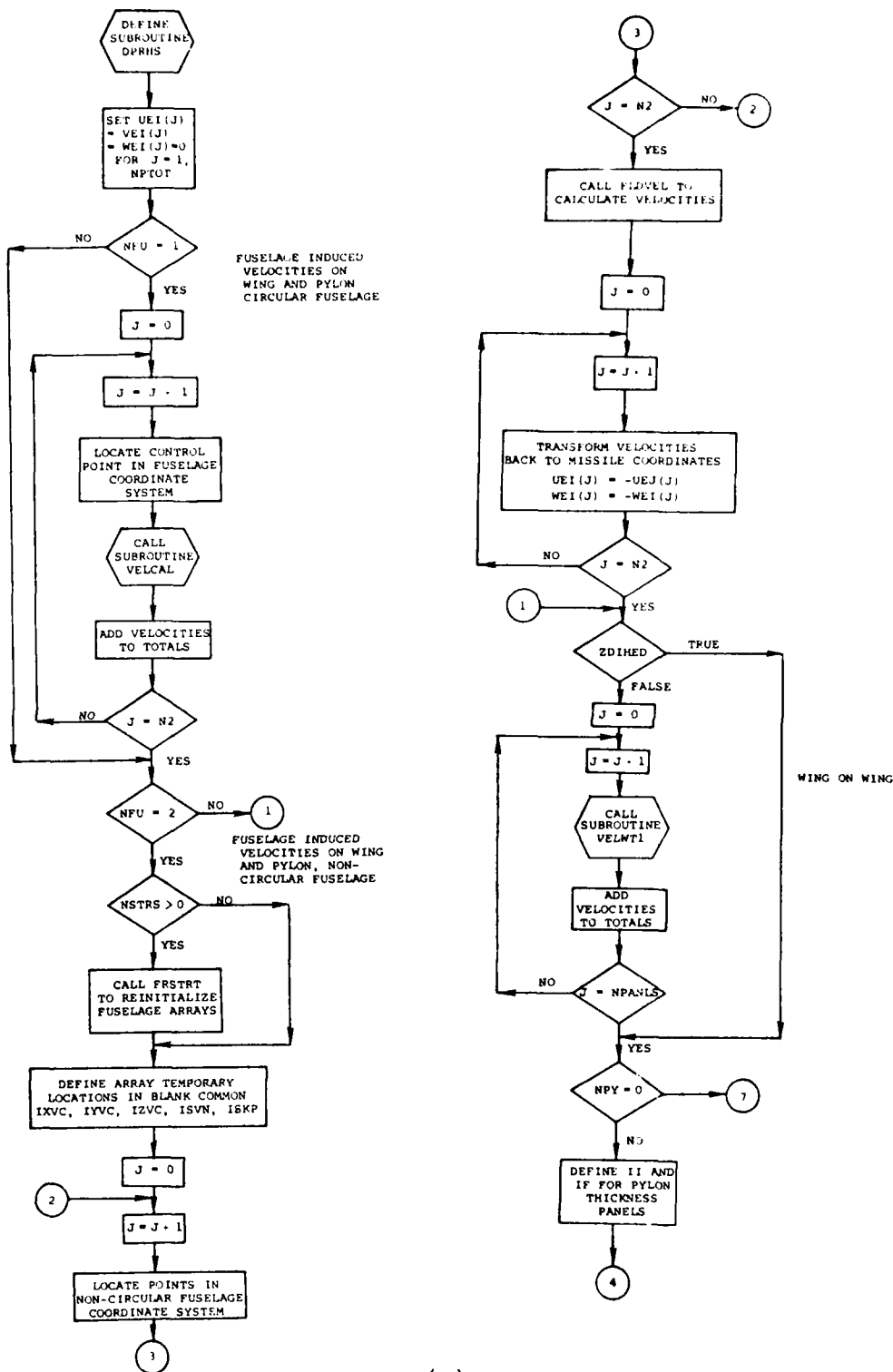
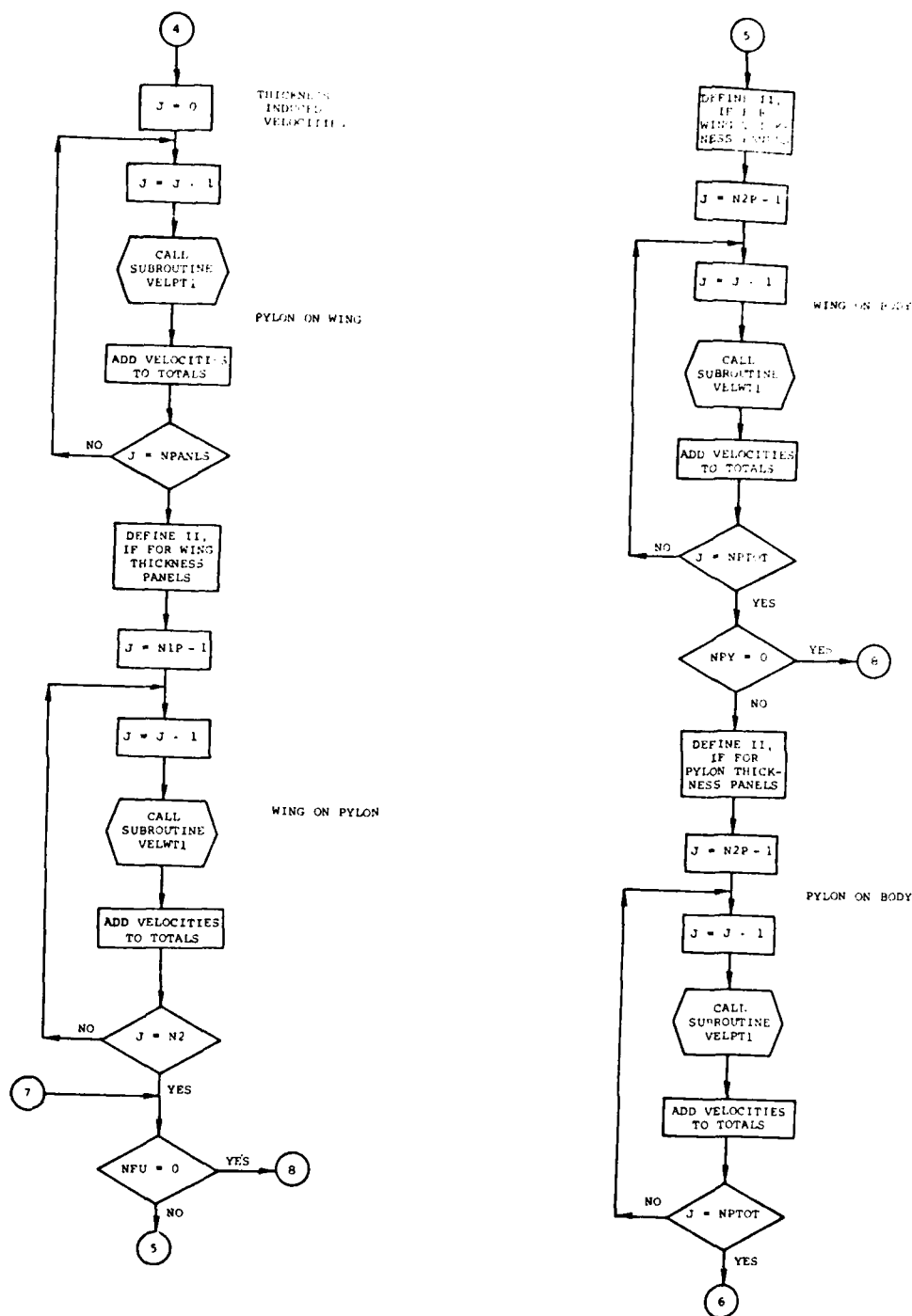
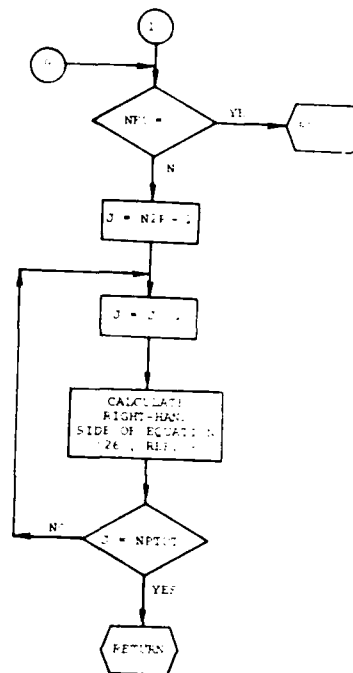
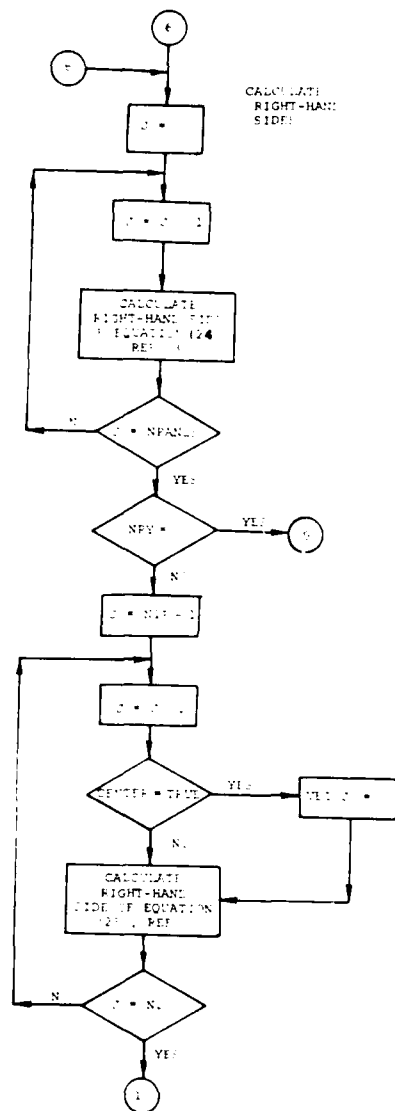


Figure A-6.- Flow chart of subroutine DPRHS.



(b)

Figure A-6.- Continued.



(c)
Figure A-6.- Concluded.

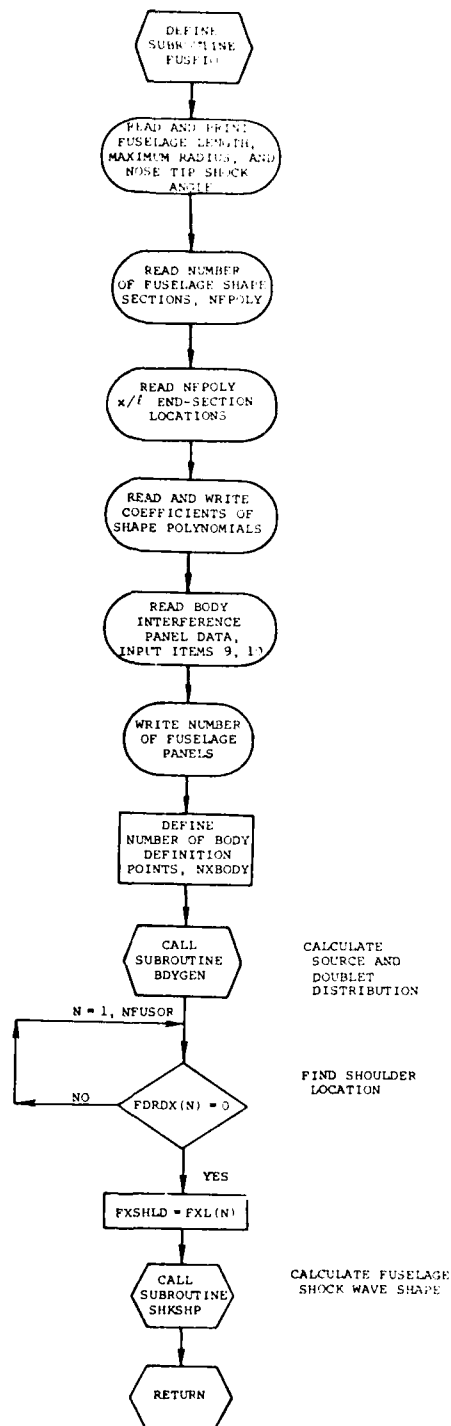
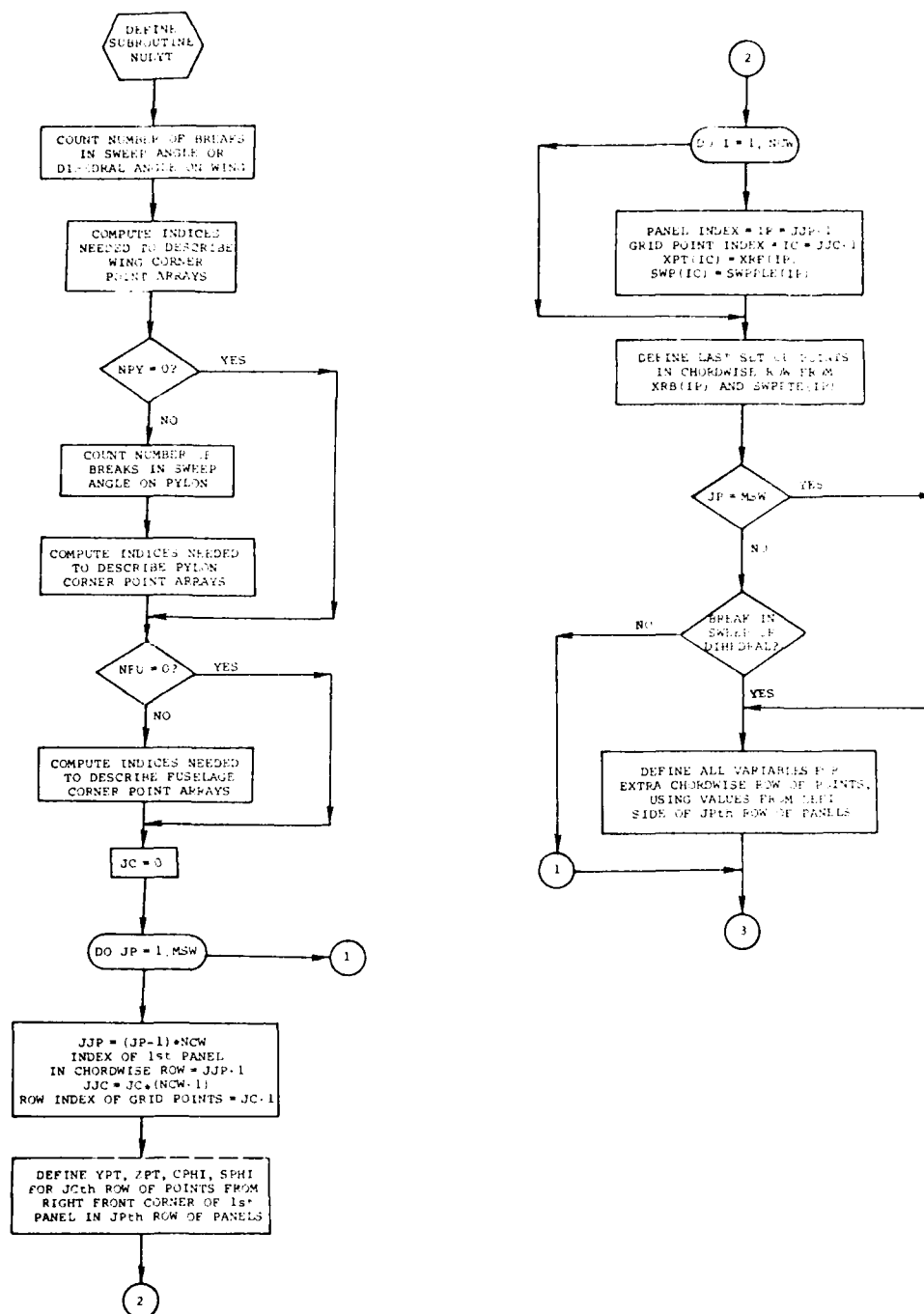
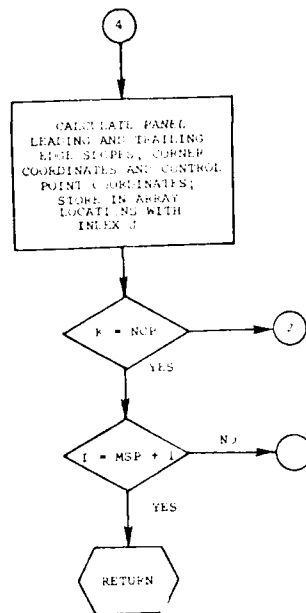


Figure A-7.- Flow chart of subroutine FUSEIO.



(a)

Figure A-8.- Flow chart of subroutine NULYT.



(b)

Figure A-9.- Concluded.

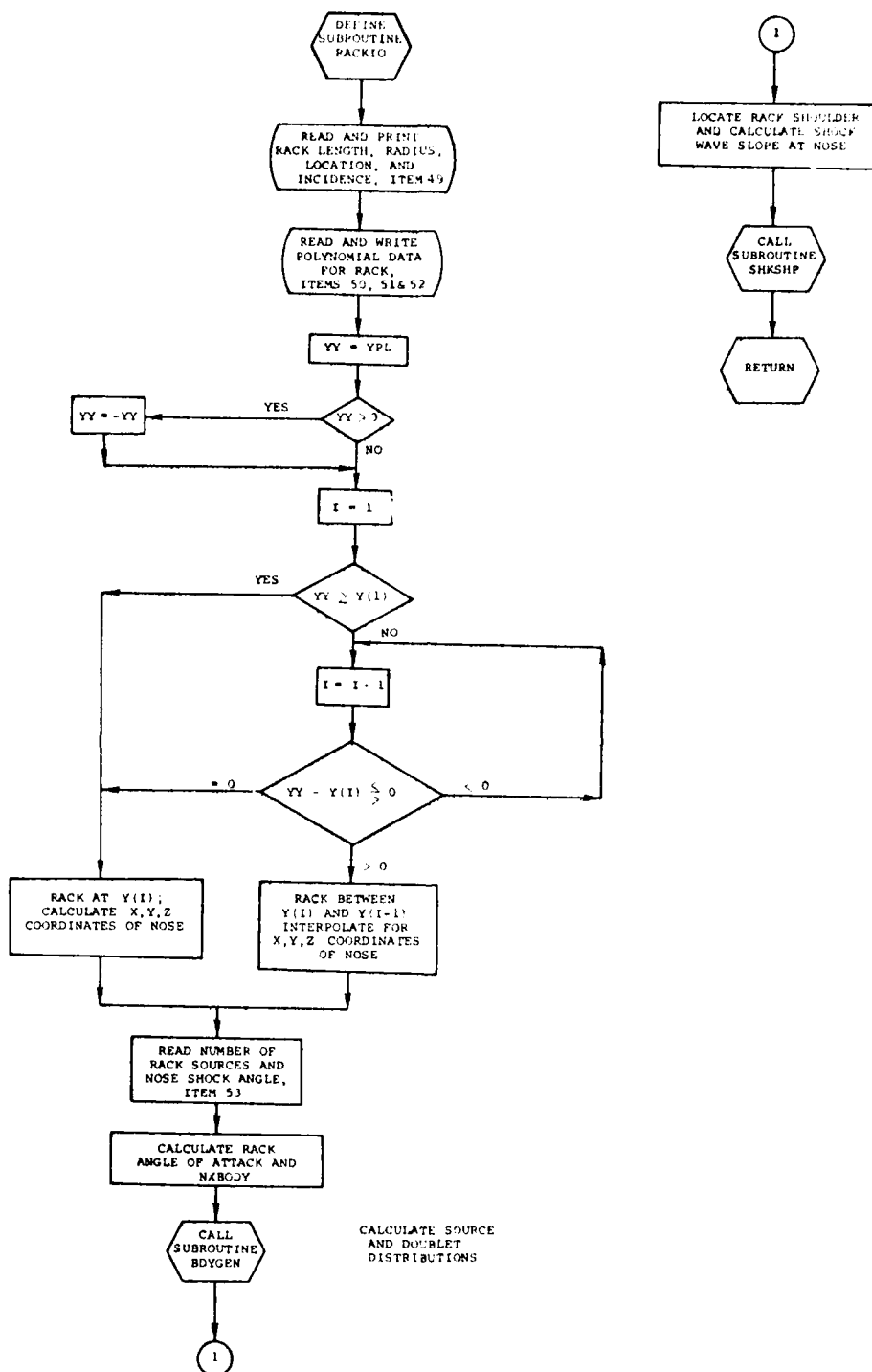


Figure A-10.- Flow chart of subroutine RACKIO.

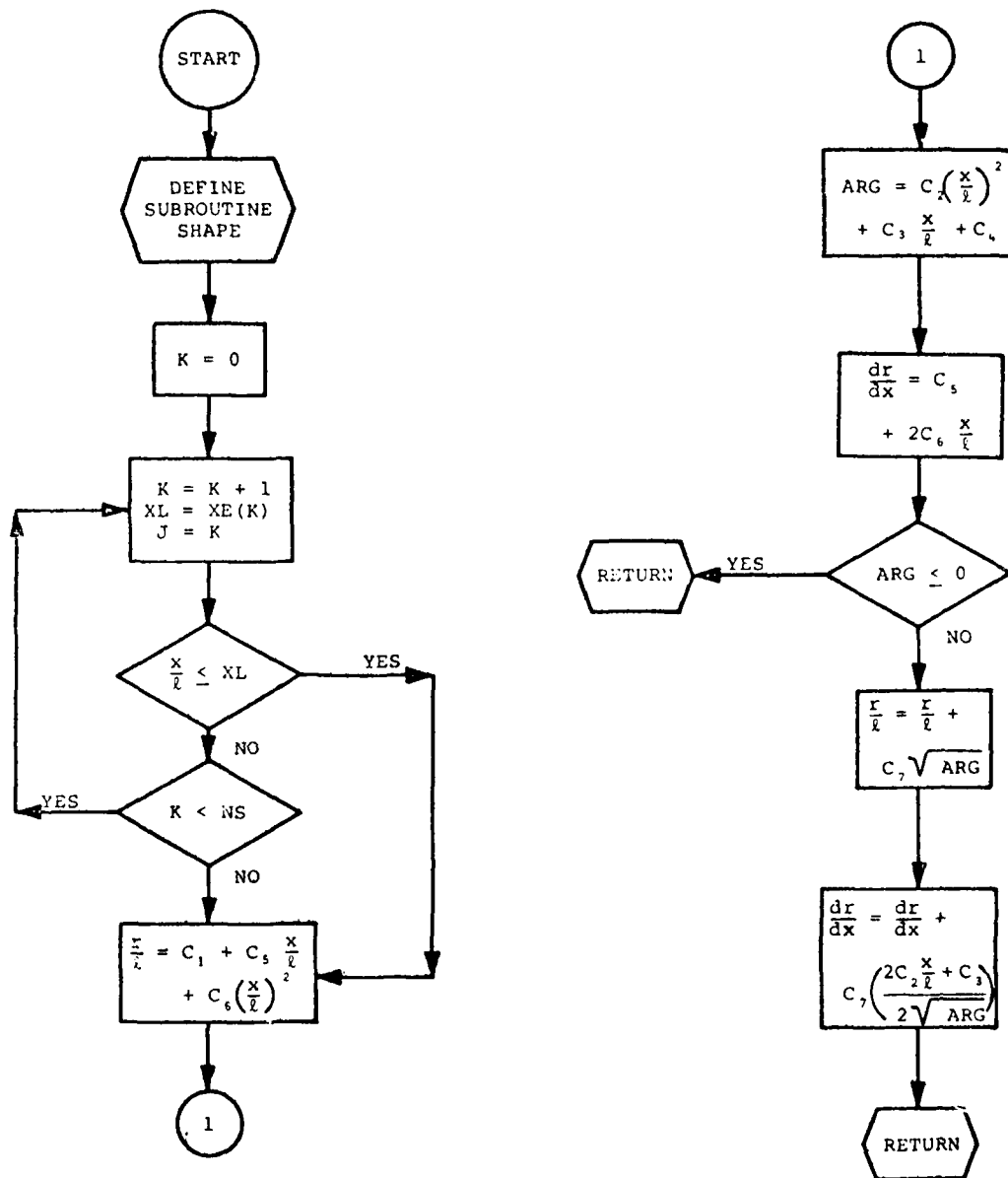
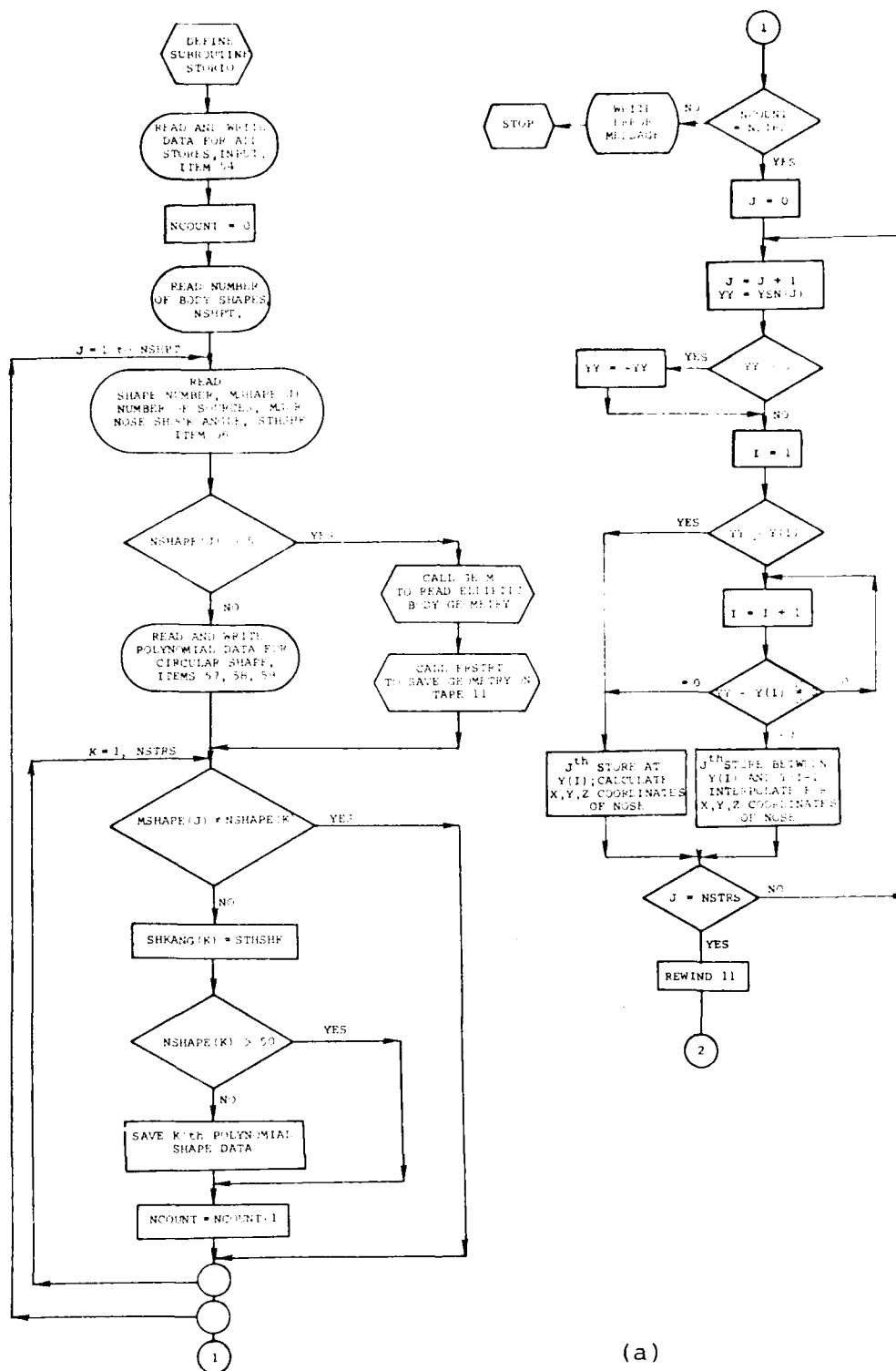
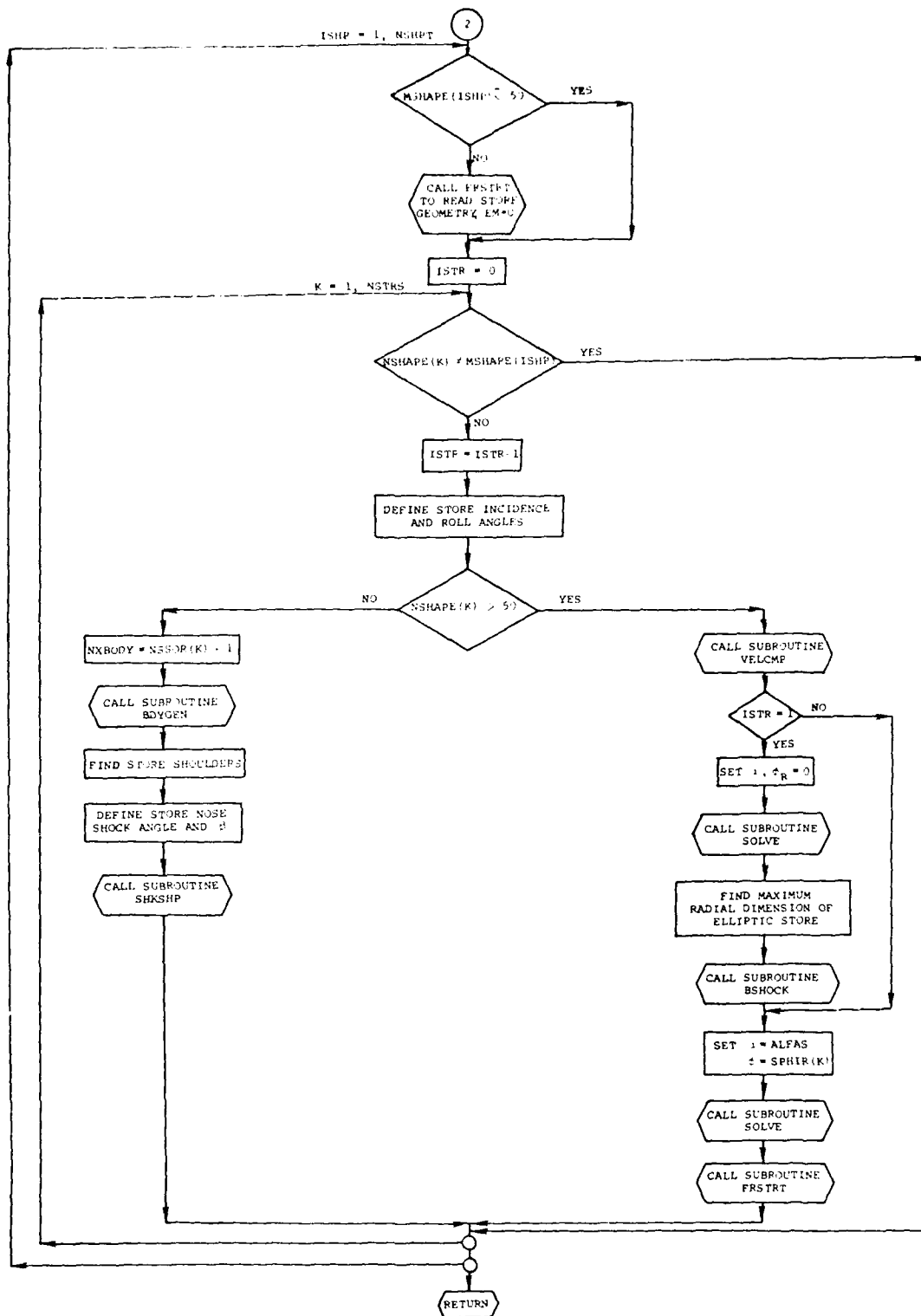


Figure A-11.- Flow chart of subroutine SHAPE.

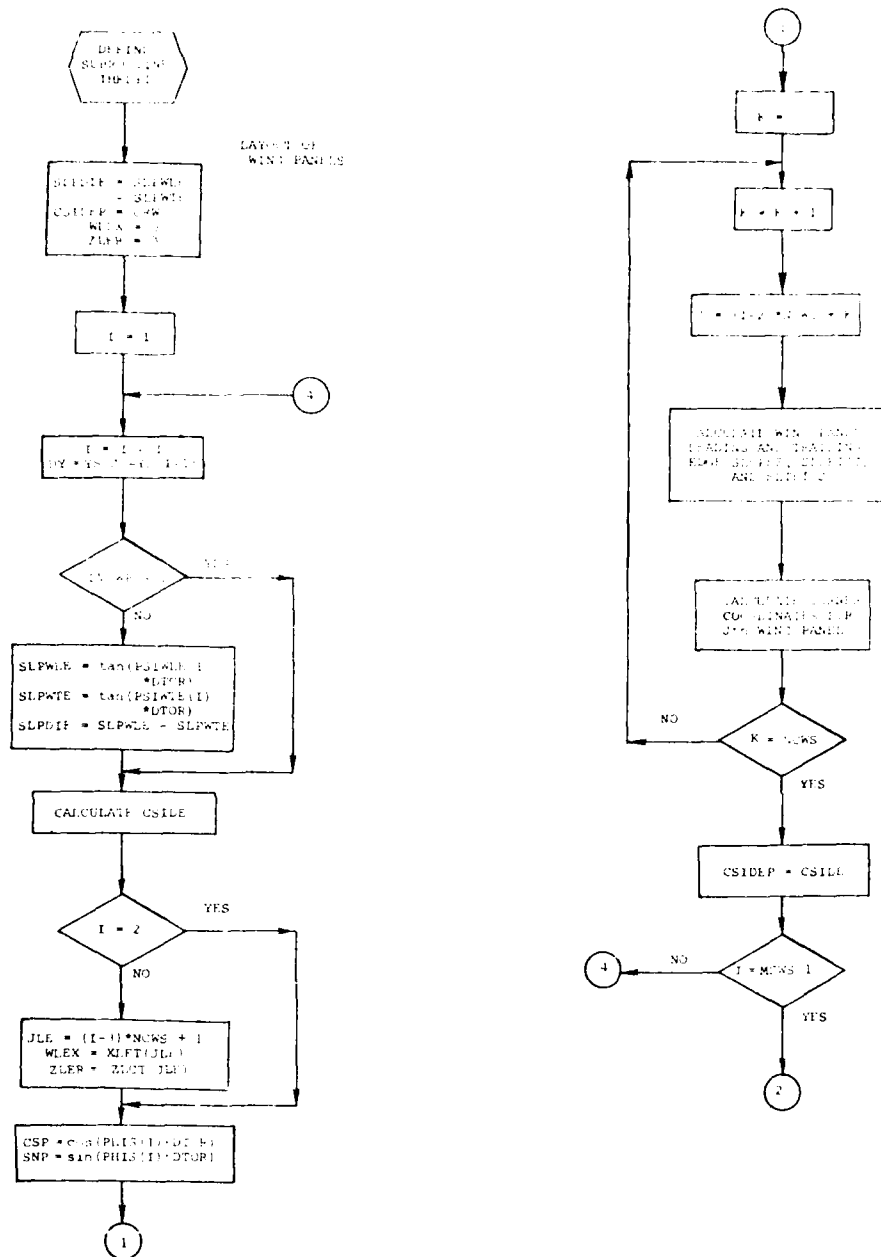


(a)

Figure A-12.- Flow chart of subroutine STORIO.

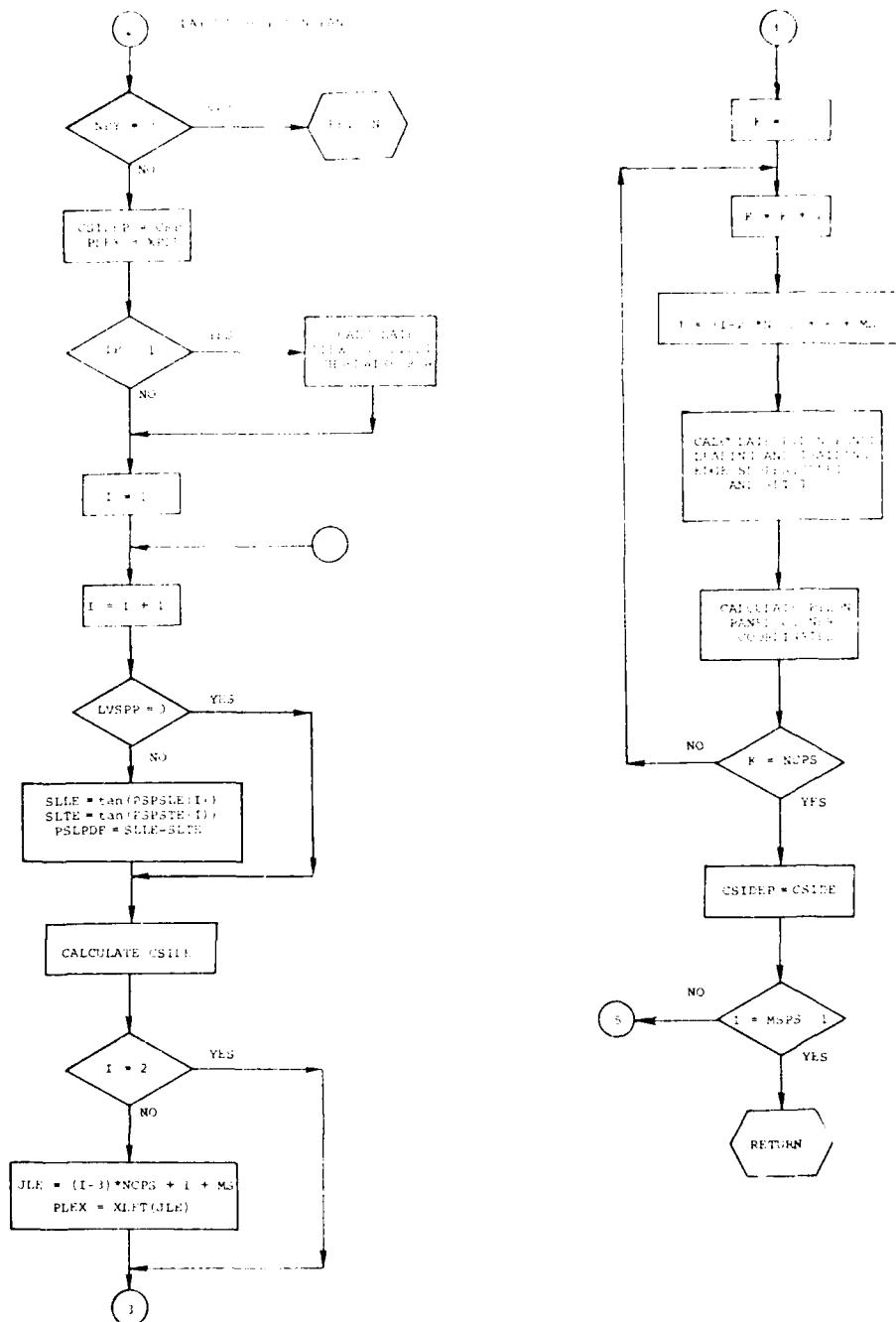


(b)
Figure A-12.- Concluded.

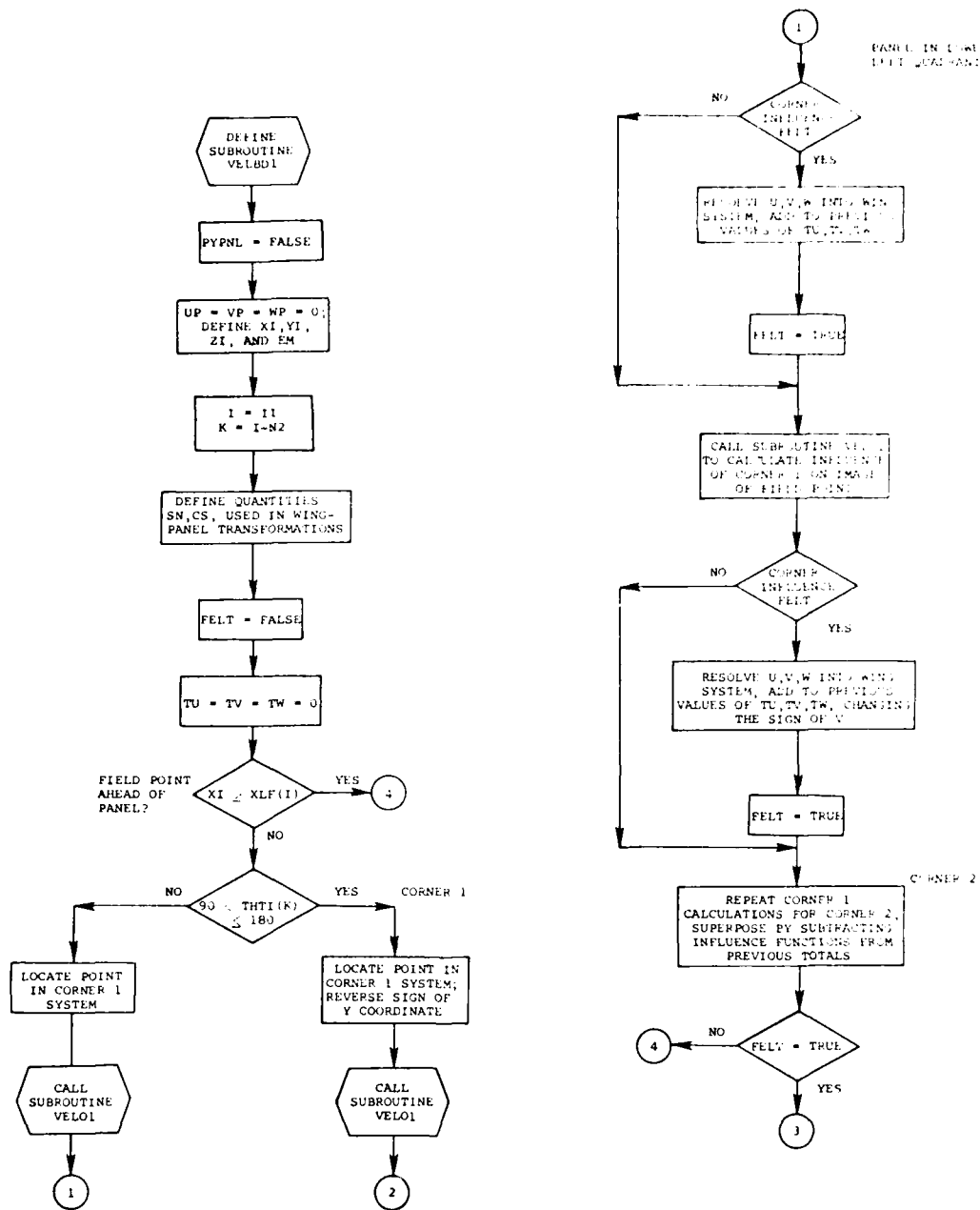


(a)

Figure A-13.- Flow chart of subroutine THKLYT.

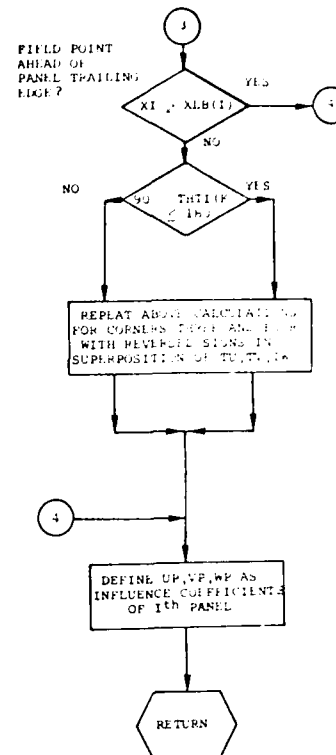
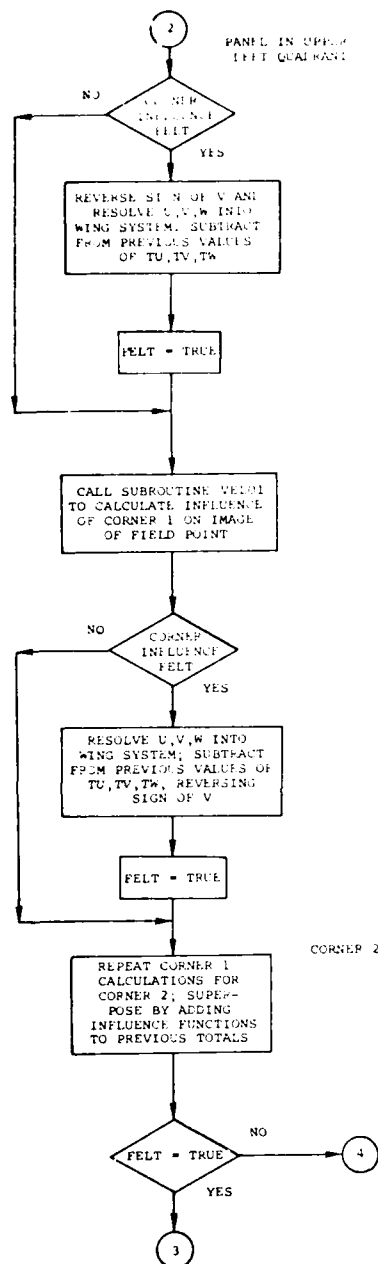


(b)
Figure A-13.- Concluded.



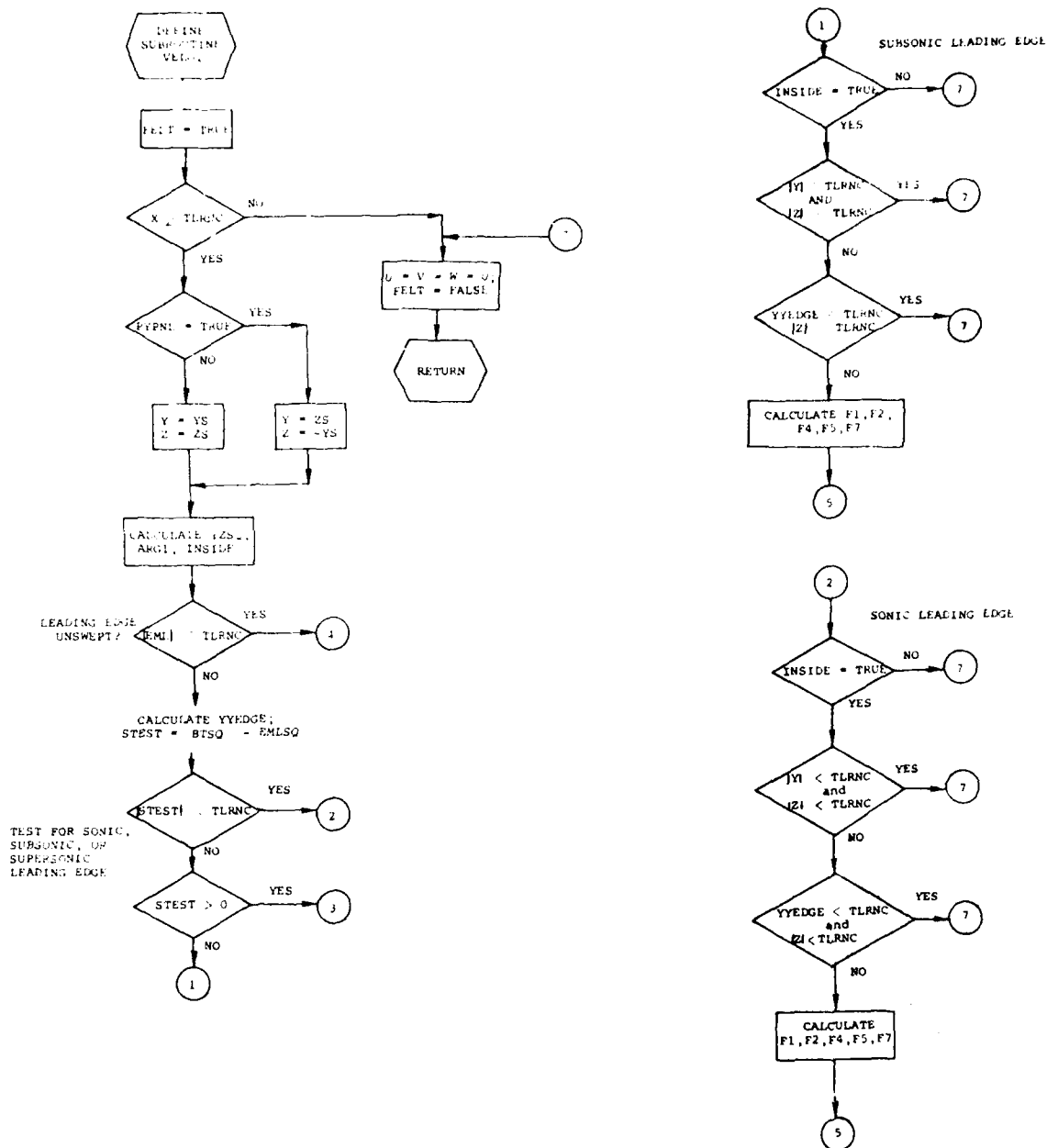
(a)

Figure A-14.- Flow chart of subroutine VELBD1.



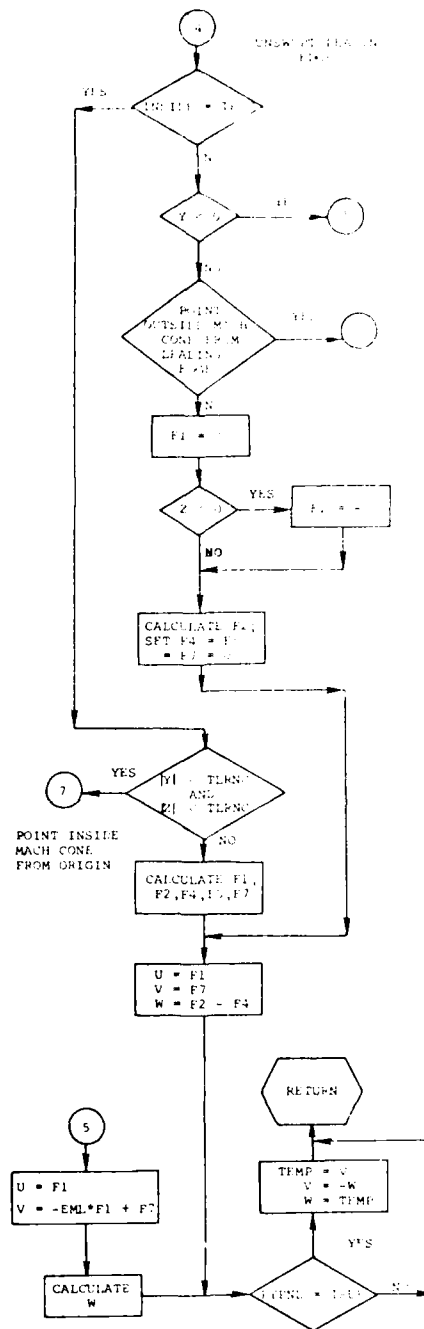
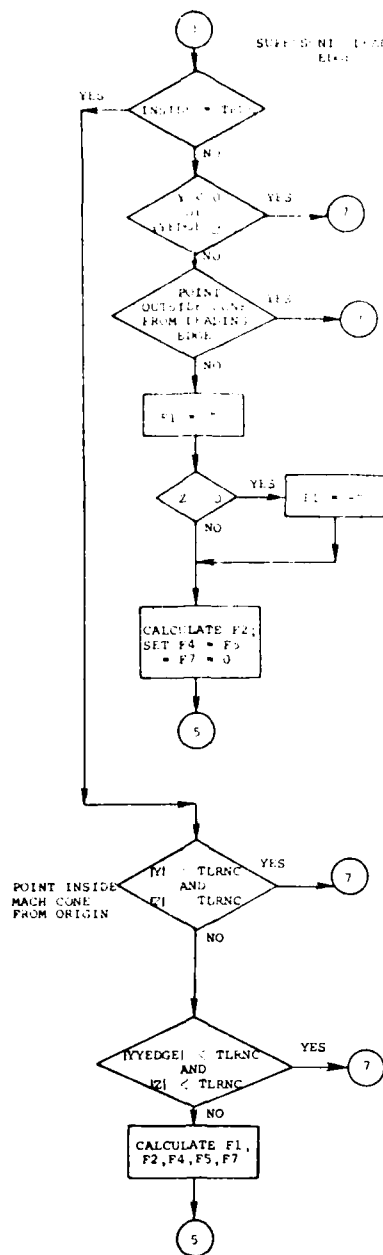
(b)

Figure A-14.- Concluded.

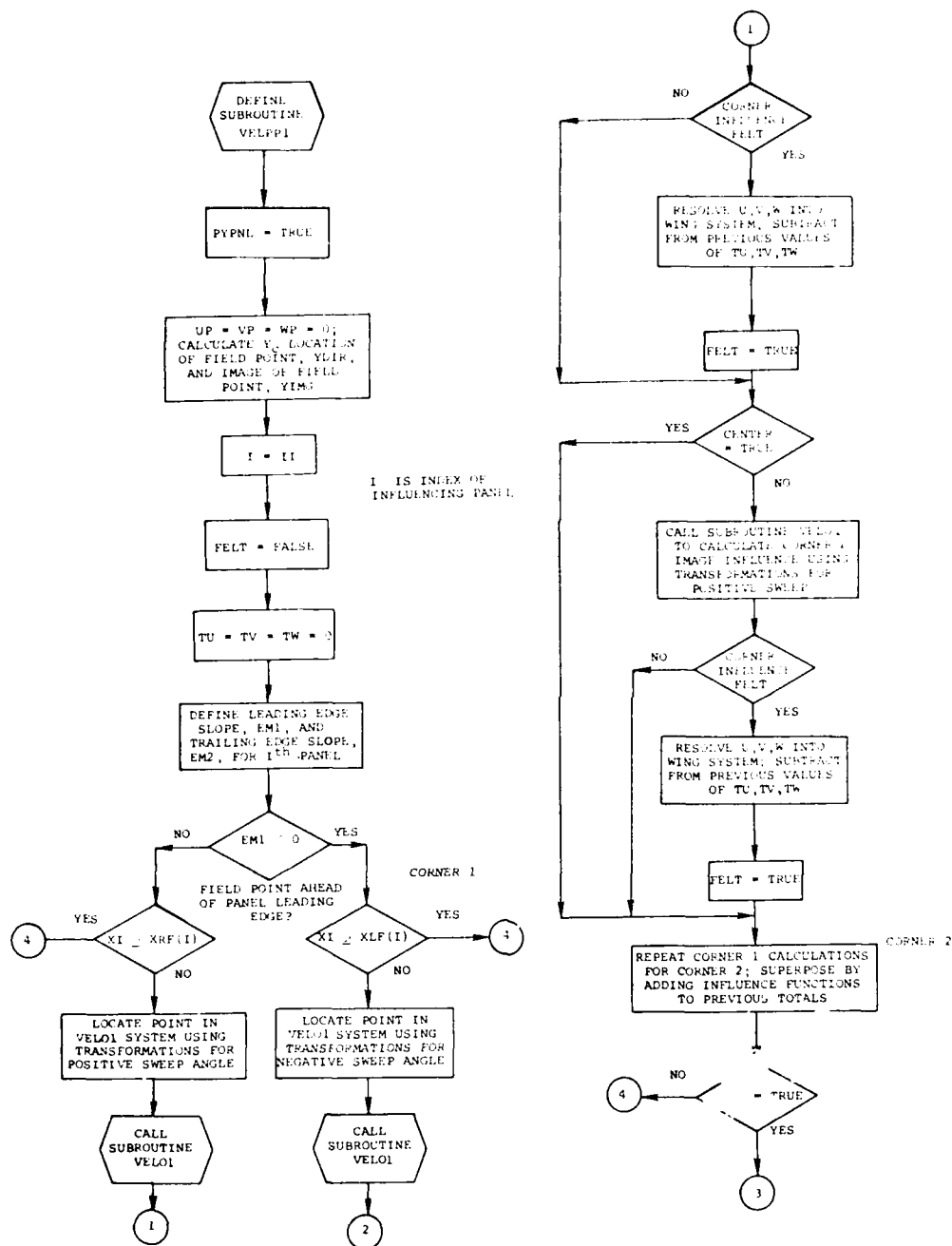


(a)

Figure A-15.- Flow chart of subroutine VELO1.

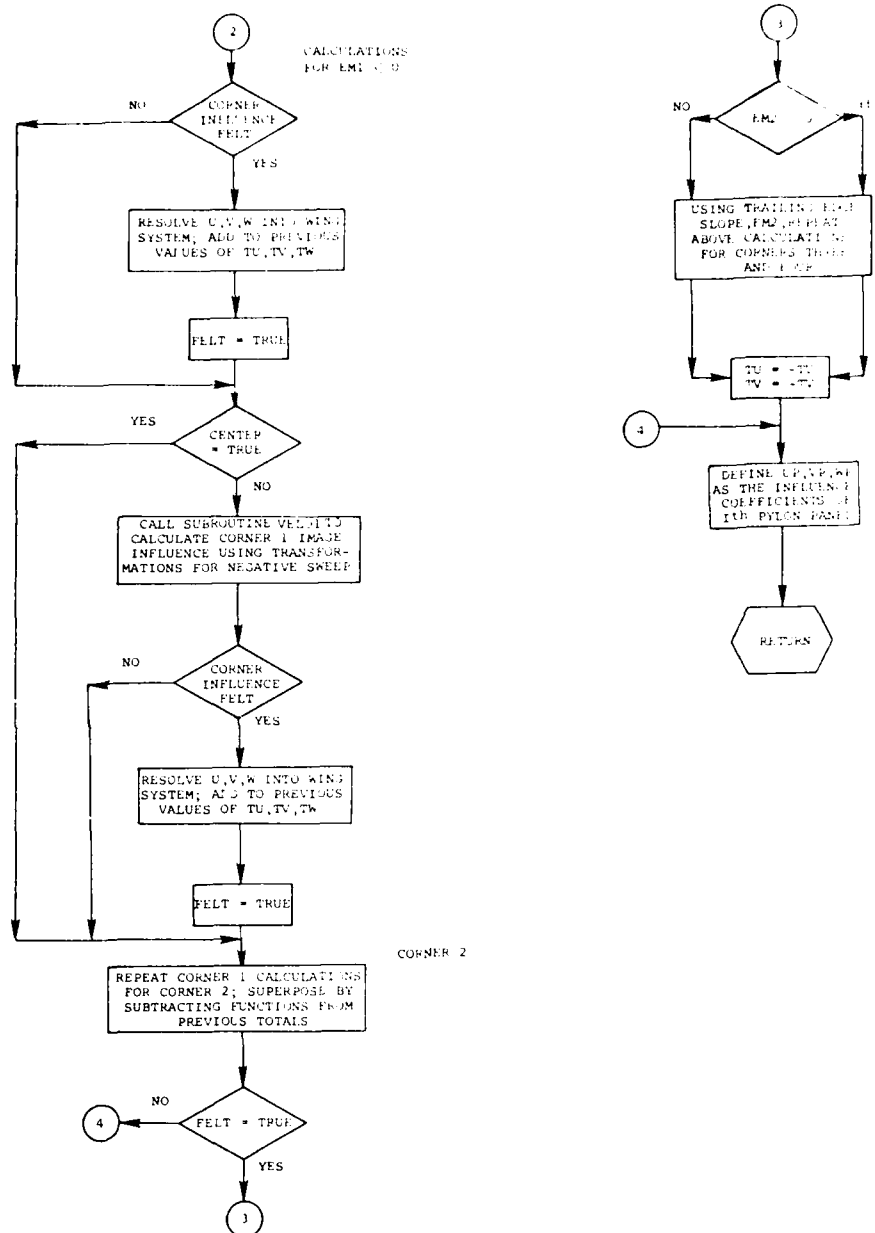


(b)
Figure A-15.- Concluded.

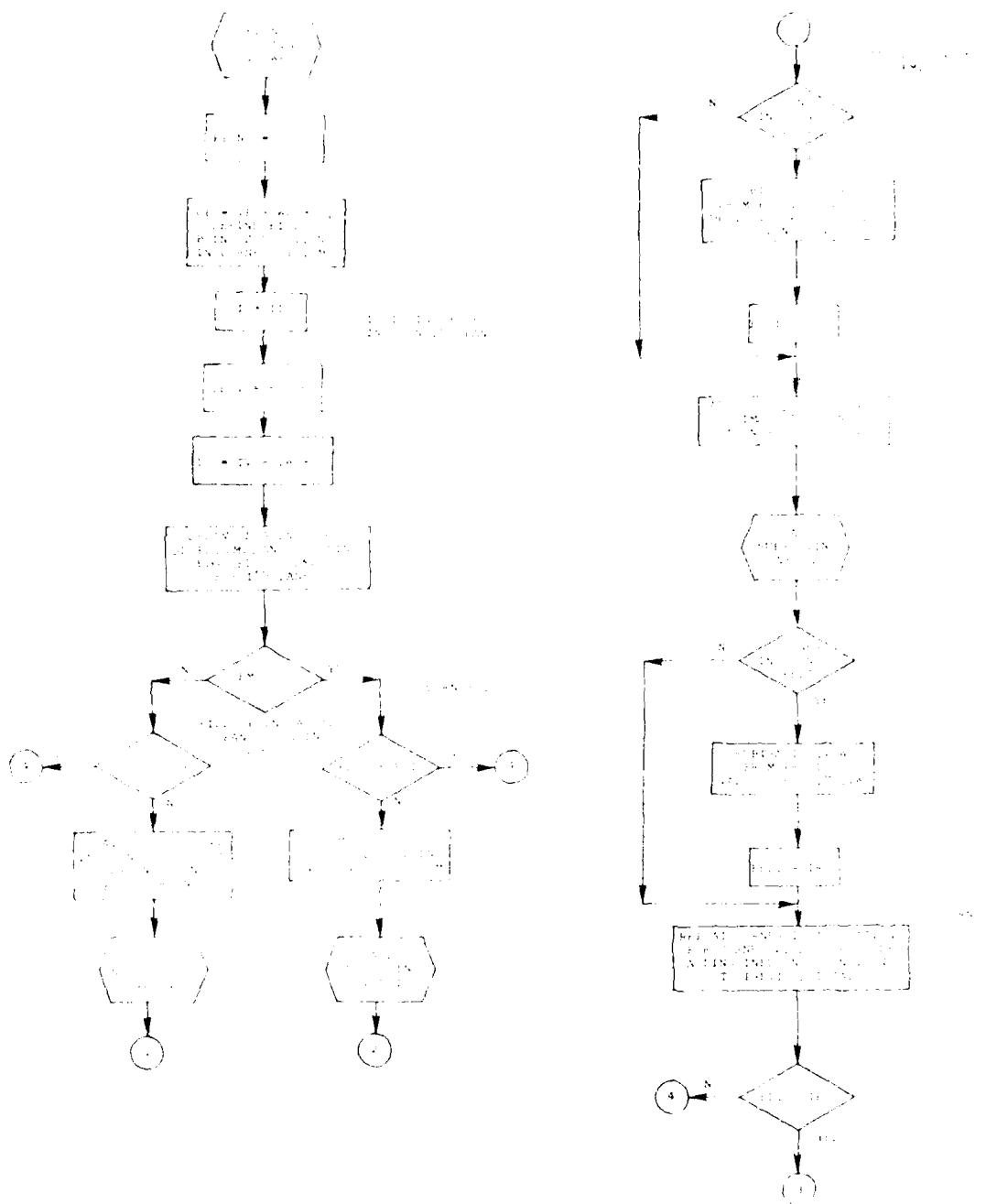


(a)

Figure A-16.- Flow chart of subroutine VELPP1.



(b)
Figure A-16.- Concluded.



(a)

Figure A-17.- Flow chart of subroutine CHWPL.

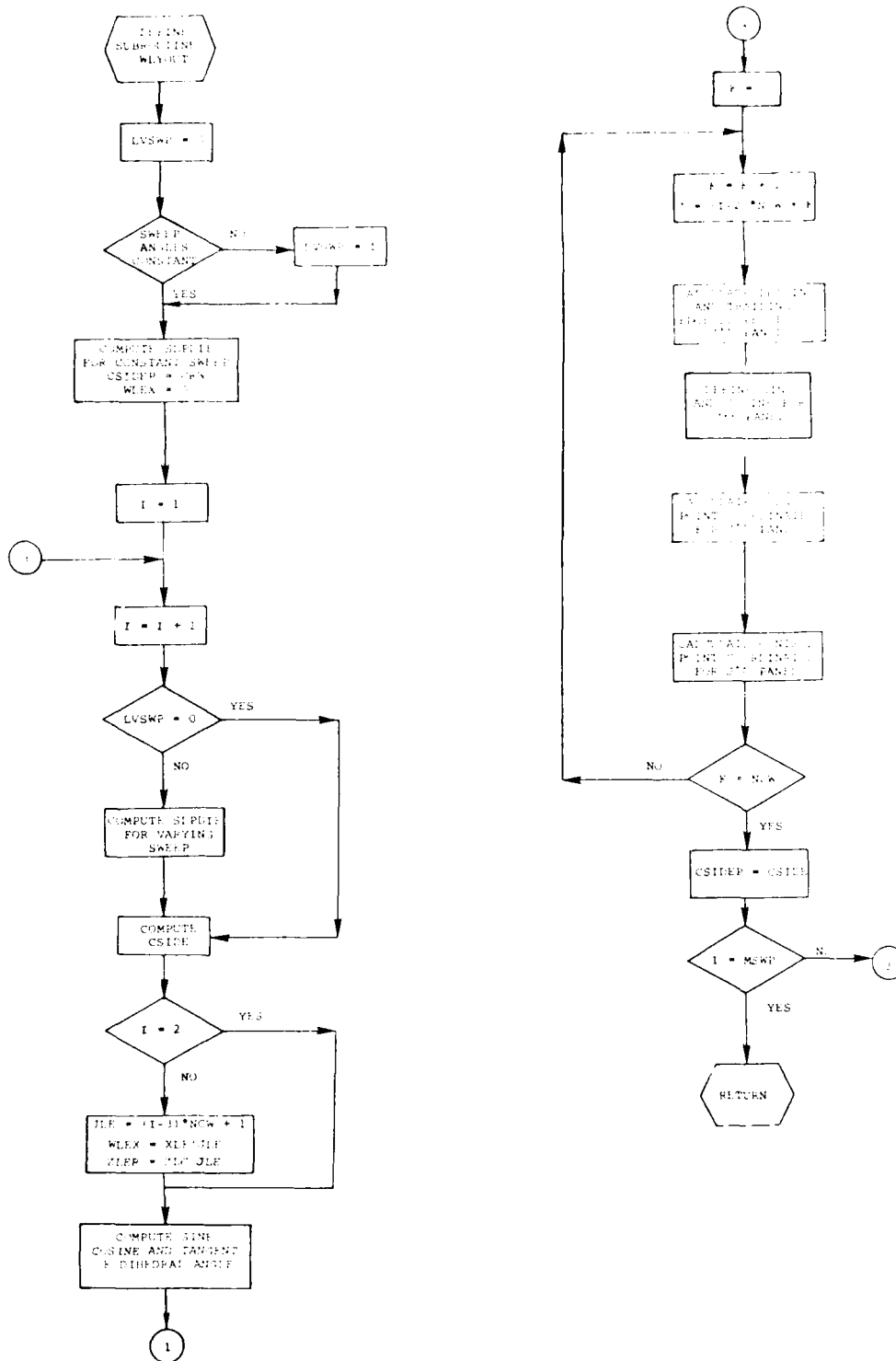


Figure A-18.- Flow chart of subroutine WLYOUT.

APPENDIX B
COMMON BLOCK DESCRIPTIONS - PROGRAM I

B-1 Introduction

The purpose of this Appendix is to provide more detailed information on the variables passed between routines through common blocks in Program I. This appendix will present the tables equating program notation to the algebraic notation and variable descriptions. The common blocks are arranged alphabetically. It is followed by a section detailing the special usage of blank common. When a description identifies an item as an input, consult Volume II of this report for further definitions. For variables used both in the description of the noncircular fuselage and elliptic stores, only the input item for the fuselage will be referenced.

A cross-reference chart showing the routines and the common statements contained in each is presented in Figure B-1. Across the top of the chart are the subroutine names including the main program LDCALC. Down the side of the page are the common names. The last one is blank common.

B-2 Description of Variables in Labeled Commons

Var.	Engr. Symbol and Description
COMMON /BASESG/ FBASE,FSUMK,FSUMKD,RBASE,RSUMK,RSUMKD,SBASE(7), SSUMK(7),SSUMKD(7)	
FBASE	fuselage x-station at which base singularities originate, feet
FSUMK	strength of source originating at fuselage base
FSUMKD	strength of doublet originating at fuselage base
RBASE	rack x-station at which base singularities originate, feet
RSUMK	strength of source originating at rack base
RSUMKD	strength of doublet originating at rack base

SBASE store x-station at which base singularities
 originate, feet

SSUMK strength of source originating at store base

SSUMKD strength of doublet originating at store base

COMMON /BGEOM/ XFUS(51),ZFUS(51),FUSARD(51),FUSBY(51),FUSAZ(51),
 XJ(51),PHIK(33)

XFUS(I) x_B coordinate of Ith station used to define body
 external geometric shape, feet; input item 18

ZFUS(I) z_B coordinate of Ith station containing cambered
 offset, feet; input item 19

FUSARD(I) cross sectional area at Ith station, ft^2 ; input
 item 22

FUSBY(I) b_y , elliptic horizontal semi-axis (y-direction),
 feet; input item 23

FUSAZ(I) a_z , elliptic vertical semi-axis (z-direction),
 feet; input item 24

XJ(J) x_B coordinate of Jth station used to define body
 panel corners, feet; input item 32

PHIK(J) ϕ_k , polar angle defining Jth meridian of panel
 edges, degrees; input item 31

COMMON /BINLET/ NINLET,NINVEL,NTINL,RVIVO,NINBLK,BTINLT,YCPI,
 XINLT,YINLT,ZINLT,XINLTE,YINLTE,ZINLTE,JINLT(25)

NINLET number of open inlet panels; input item 14

NINVEL number of additional panels to be used in velocity
 calculations for inlet panels; input item 14

NTINL total number of inlet panels to be used in a given
 calculation

RVIVO inlet mass flow ratio; ratio of open inlet panel
 frontal area to total inlet panel area

NINBLK number of blocked inlet panels; input item 14

BTINLT β associated with inlet panels; input item 29

YCPI y-location of inboard most edge of inlet panels

XINLT,
 YINLT,
 ZINLT coordinates of outboard leading edge of inlet panels
 used to locate center of inlet shock propagation

ZINLTE,
 YINLTE,
 ZINLTE coordinates of outboard trailing edge of inlet
 panels used to locate lower lip of inlet and
 turning point of shock

JINLT(I) fuselage panel number associated with Jth inlet
 panel

COMMON /BINSHK/ NIS,XISHLD,EALPI,XCLOSD,MAXSHI,NINL(8),PHINL(8),
 YINL(8),XINL(80),RINL(80)

NIS number of inlet shock traverses; input item 28

XISHLD x-station at which α 's associated with inlet return
 to free stream

EALPI angle of attack correction factor for inlet
 shock (EALPHA)

XCLOSD x-location of leading edge of blocked inlet panels

MAXSHI maximum number of points in inlet shock tables per
 traverse (=MAXSHK)

NINL(I) number of points computed for Ith shock traverse

PHINL(I) angle measured from z-axis below inlet of Ith
 inlet shock traverse, positive counterclockwise

YINL(I) y-station of Ith inlet shock traverse

XINL table of x-values of inlet shock

RINL table of radial values of inlet shock

COMMON /BIPYZ/ XBIP,NYZBIP,YCB(33),ZCB(33)

XBIP x-station at which the y,z geometry used in the
 definition of the body interference shell are
 obtained for the noncircular fuselage, feet

NYZBIP number of y,z values used to define panel corners
 around the circumference of the interference shell;
 NYZBIP=KRAD of local body segment

YCB(I) y-coordinates of noncircular interference shell,
feet

ZCB(I) z-coordinates of noncircular interference shell,
feet

COMMON /BLKPAN/ COST,SINT,XBTJ,YBTJ,ZBTJ,XC1,YC1,ZC1,XPTI,YPTI,
ZPTI,COSTI,SINTI,COSD,SIND,LZERO

COST,SINT $\cos(\theta_j)$ and $\sin(\theta_j)$, cosine and sine of polar angle
of Jth influencing source panel

XBTJ XPT_j coordinate of Jth influencing control point,
feet

YBTJ YPT_j coordinate of Jth influencing control point,
feet

ZBTJ ZPT_j coordinate of Jth influencing control point,
feet

XC1 x_B coordinate of Jth panel reference corner, feet

YC1 y_B coordinate of Jth panel reference corner, feet

ZC1 z_B coordinate of Jth panel reference corner, feet

XPTI XFT_i coordinate of Ith influenced field point, feet

YPTI YFT_i coordinate of Ith influenced field point, feet

ZPTI ZFT_i coordinate of Ith influenced field point, feet

COSTI,SINTI $\cos(\theta_i)$ and $\sin(\theta_i)$, cosine and sine of polar angle
at Ith influenced panel or field point

COSD,SIND $\cos(\delta_i)$ and $\sin(\delta_i)$, cosine and sine of panel
incidence angle at Ith influenced panel or field
point

LZERO PANVEL angle calculation option: F=yes, T=no

COMMON /BODCOM/ AMACH,TAND,CX,XCOR(4),YCOR(4),ZCOR(4),XI,YI,XJ,
ZJ,BETA0,BETAL,SUBSON,SUPERS

AMACH Mach number used in source panel influence
calculation

TAND	$\tan \delta_j$, tangent of incidence angle of Jth influencing panel
CX	panel chord length, feet
XCOR(K)	x of Kth corner in local panel system, feet
YCOR(K)	y of Kth corner in local panel system, feet
ZCOR(K)	z of Kth corner in local panel system, feet
XI	x of Ith field point in local panel system, feet
YI	y of Ith field point in local panel system, feet
ZI	z of Ith field point in local panel system, feet
XJ	x of Jth panel control point in panel system, feet
ZJ	z of Jth panel control point in panel system, feet
BETA0	$\sqrt{M_\infty^2 - 1}$, free stream Mach number constant
BETAL	$\sqrt{M_\ell^2 - 1}$, local Mach number constant
SUBSON	subsonic logical indicator; SUBSON = AMACH.LT.1
SUPERS	supersonic logical indicator; SUPERS = AMACH.GT.1
COMMON /BOPTNS/ J0,J2,J6,NFUS,NRADX(5),NFORX(5),J2TEST,IPRES,ISOLV, INLET,IPLOT(4),IPRT(5),IUUV,XSTART,XWLE,REFA,REFD,REFL,REFX, CCTEST,ITMAX,BODL,IZ1(12)	
J0	reference area indicator; see input item 16
J2	body type indicator; see input item 16
J6	body camber indicator; see input item 16
NFUS	number of body segments; see input item 16
NRADX(I)	number of points used to define section of Ith body segment
NFORX(I)	number of axial station on Ith body segment
J2TEST	parameter to specify body camber and cross-section definition
IPRES	not used
ISOLVE	not used

INLET	logical inlet indicator: true = inlet panels present false = no inlet panel present
IPLOT	not used
IPRT	optional print control parameter, see input item 14
IUVW	component velocity calculation option; see input item 14
XSTART	x-station at which pressure integration is started, feet
XWLE	x-station at which pressure integration is ended, feet
REFA	body reference area, ft^2 ; see input item 17
REFD	body reference length used for moment normalization, feet; see input item 30
REFL	body length, feet; see input item 30
REFX,REFZ	x,z coordinates of moment reference point, feet; see input item 30
CCTEST	solution convergence control criteria (=0.0001)
ITMAX	solution maximum number of iterations (=20)
IZ1	dummy array, not used
COMMON /BPGEOM/ SNT2(200),CST2(200),ZLC(200),ZRC(200),THTI(200), SANGW	
SNT2(J)	$\sin(\text{ANG}_J)$ associated with Jth body panel
CST2(J)	$\cos(\text{ANG}_J)$ associated with Jth body panel
ZLC(I)	z_W coordinate of left edge of Ith constant u-velocity panel
ZRC(I)	z_W coordinate of right edge of Ith constant u-velocity panel
THTI(J)	$(1 - \text{THT}_J)$; THT_J is value of THT associated with Jth panel
SANGW	$\sin(\text{ANGW}) = \text{ZBWO}/\text{FRMAX}$

COMMON /BSHOCK/ NSHK(10),PHIS(10),THETN(10),MAXSHK,NSHOCK,DBETA,
EALPHA,CNU0,CNU2,XSHLDR,CHE(3),XSH(100),RSHK(100)

NSHK(I) number of points used to represent Ith modified
 shock shape

PHIS(I) polar angle at which Ith modified shock is computed,
 degrees; input item 33

THETN(I) nose limited shock angle of initial shock shape
 at Ith polar angle, degrees

MAXSHK maximum number of points in Ith shock shape; input
 item 14

NSHOCK number of modified shock shape computed; input
 item 14

DBETA not used

EALPHA angle of attack correction to shock shape; input
 item 15

CNU0,CNU2 not used

XSHLDR x_B location of body nose shoulder, feet; input
 item 15

SHK dummy array, not used

XSHK,RSHK arrays containing x_B and r_B locations of NSHOCK
 sets of NSHK(I) points representing the modified
 nose shock shape, feet

COMMON /CAMBER/ ALPHAL(200)

ALPHAL(J) $\tan(\epsilon)$, slope of wing camberline at the constant
 u-velocity panel control points; input item 39

COMMON /CONFIG/ NFU,NPY,NSTRS,LVSWP,NRACK

NFU fuselage indicator; input item 4

NPY pylon indicator; input item 4

NSTRS number of stores indicator; input item 4

KFORX(I)	number of axial stations used to define leading and trailing edges of panels on Ith body segment; input item 27
IXC(I)	location in blank common of start of XC array for Ith body segment
IYC(I)	location in blank common of start of YC array for Ith body segment
IZC(I)	location in blank common of start of ZC array for Ith body segment
IXZSYM	XZ-plane symmetry option; input item 14
NADIM	dimensioned length of A array in blank common
NXDIM	maximum allowable number of axial stations (=51)
NG	last location in blank common containing source panel geometry arrays
IXPT	location in blank common of start of control points, XPT
IYPT	location in blank common of start of control points, YPT
IZPT	location in blank common of start of control points, ZPT
ITH	location in blank common of start of array THET
IDEL	location in blank common of start of array DELTA
NTAP7	number of variables last written on TAPE7
IAR	location in blank common of start of panel areas, AREA
IAN	location in blank common of start of temporary array AN containing influence coefficients
IUB	location in blank common of start of temporary array UB containing U,V,W influence coefficients
IGB(IALP)	location in blank common of start of IALPth array containing the source strength solution, GB
IVB	location in blank common of start of temporary array, VB, containing normal velocity boundary conditions

IU	location in blank common of start of U velocities
IV	location in blank common of start of V velocities
IW	location in blank common of start of W velocities
IWA, IWA	location in blank common of start of additional temporary velocity arrays
ICP	location in blank common of start of pressure coefficient, CP, array
IPHI	location in blank common of temporary PHI array
ITB	location in blank common of start of coordinates YB and ZB of temporary cross section geometry in NEWRAD
NAG	maximum locations in blank common required in GEOM
NAP	not used
NAV	maximum locations in blank common required in VELCMP
NAS	maximum locations in blank common required in SOLVE
NASHK	maximum locations in blank common required in BSHOCK
NAFLD	maximum locations in blank common required in FLDVEL
IAO	offset location in blank common of all above arrays when multiple configurations are simultaneously in core
IDO	offset location in blank common of ID array containing /DIMENS/ information for additional source panel configurations in core
ISKO	offset location in blank common of array containing information in common /BSHOCK/ for additional source panel configurations in core
IYIM, IZIM	location in blank common of start of image store Y and Z control point coordinates
ISVN, ISKP	location in blank common of start of temporary arrays, SVN and LSKP
NRING	number of rings of panels on body
IROW(I)	number of panels around Ith ring of panels

COMMON /EXVEL/ UEI(200),VEI(200),WEI(200),CIR(200)

UEI(I) $u_{W_i,v}/V_\infty$ at the $v = I$ th control point
 VEI(I) $v_{W_i,v}/V_\infty$ at the $v = I$ th control point
 WEI(I) $w_{W_i,v}/V_\infty$ at the $v = I$ th control point
 CIR(I) array containing right-hand sides of u-velocity equations

COMMON /FLOW/ ALFACR,GAMF,FMACH,RHO,VINF,BETA,BETASQ,FMCHSQ

ALFACR α_f , radians
 GAMF not used
 FMACH M_∞ ; input item 3
 RHO not used
 VINF not used
 BETA $\beta = \sqrt{M_\infty^2 - 1}$
 BETASQ β^2
 FMCHSQ M_∞^2

COMMON /FSGEOM/ FRMAX,SSPAN,FLTHC,BODYPL

FRMAX fuselage maximum radius; input item 5
 SSPAN wing semispan, feet; input item 35
 FLTHC fuselage length, feet; input item 5
 BODYPL body interference shell length, feet; input item 10

COMMON /FSHOCK/ NFSHK,FXSHK(50),FRSHK(50),FDRDX(101)

NFSHK number of x and r values in fuselage nose shock table generated from line singularities
 FXSHK(I),
 FRSHK(I) x and r coordinates of Ith circular fuselage nose shock location at zero angle of attack
 FDRDX(J) DR/DX at Jth circular fuselage control point

COMMON /FSOR/ FXL(101),FSS(100),FDS(100),NFSOR

FXL array containing the x positions of the fuselage
sources; positive, measured from tip of nose

FSS array containing the strengths of the circular
fuselage source distribution

FDS array containing the strengths of the circular
fuselage doublet distribution

NFSOR number of circular fuselage sources and doublets;
input item 9

COMMON /HEAD/ TITLE1(20),TITLE2(20)

TITLE1 array containing hollerith description of non-
circular body external geometry

TITLE2 array containing hollerith description of non-
circular body paneling distribution

COMMON /ICVEL/ UP,VP,WP,II,IF,DELTP(200)

UP u/V_{∞} perturbation velocity at a control point due
to pylon or wing thickness; also u-velocity panel
u influence function at a control point

VP v/V_{∞} perturbation velocity at a control point due
to pylon or wing thickness; also u-velocity panel
v influence function at a control point

WP w/V_{∞} perturbation velocity at a control point due
to pylon or wing thickness; also u-velocity panel
w influence function at a control point

II,IF initial and final values, respectively, of thickness
panel index

DELTP $1/\pi(u_+/V_{\infty})$; u-velocity panel strength

COMMON /INDEX/ NCW,MSW,MSWP,NPANLS,NCWB,NBDCR1,NBDCR2,NBD,NBIP,
MP,NCP,MSP,N1P,N2,N2P,NPTOT

NCW number of wing panels chordwise, input item 36

MSW number of wing panels spanwise, input item 36

MSWP MSW+1

NPANLS number of u-velocity panels on left wing panel:
NCW*MSW

NCWB number of BIP rings, input item 9
 NBD total number of fuselage u-velocity panels in a
 ring on the half body
 NBIP number of u-velocity panels on fuselage;
 $NBIP = NBD * NCWB$
 MP number of u-velocity panels on pylon;
 $MP = NCP * MSP$
 NCP number of pylon panels chordwise, input item 44
 MSP number of pylon panels spanwise, input item 44
 N1P $NPANLS + 1$
 N2 $NPANLS + MP$
 N2P $N2 + 1$
 NPTOT $NPANLS + MP + NBIP$

COMMON /NUINDX/ KW,KP,NRW,NRP,NRB,NPTW,NPTP,NPTB,NRTOT,NPTT,
 NRWS,NRPS,NPTWS,NPTPS,NRTOTS,NPTTS,NRWP,NPTWP,
 NCWL,NCPL,NCWB1,NCWS1,NCPS1

KW number of breaks in sweep and/or dihedral on wing
 KP number of breaks in sweep on pylon
 NRW $NRW = MSW + KW + 1$
 NRP $NRP = MSP + KP + 1$
 NRB $NRB = 2 * NBD$
 NPTW $NPTW = NCW + NRW + 1$
 NPTP $NPTP = NCP + NRW + 1$
 NPTB $NPTB = NCWB + NRB + 1$
 NRTOT $NRTOT = NRW + NRP + NRB$
 NPTT $NPTT = NPTW + NPTP + NPTB$

NRWS	$NRWS = MSWS + RW + 1$
NRPS	$NRPS = MSPS + RP + 1$
NPTWS	$NPTWS = NCWS + NRWS + 1$
NPTPS	$NPTPS = NCPS + NRPS + 1$
NRTOTS	$NRTOTS = NRWS + NRPS$
NPTTS	$NPTTS = NPTWS + NPTPS$
NRWP	$NRWP = NRW + NRP$
NPTWP	$NPTWP = NPTW + NPTP$
NCW1	$NCW1 = NCW + 1$
NCP1	$NCP1 = NCP + 1$
NCWB1	$NCWB1 = NCWB + 1$
NCWS1	$NCWS1 = NCWS + 1$
NCPS1	$NCPS1 = NCPS + 1$

COMMON /PARAM/ XMACH, ALPHA, BETA, ALPHAC, PHIR, EM, SINAC, COSAC,
 SPHI, CPHI, SINA, SINB

XMACH	Mach number seen by source panels
ALPHA	α , free stream angle of attack seen by source panels, degrees ($=\sin^{-1}(\sin(\text{ALPHAC}) \cdot \cos(\text{PHIR}))$)
BETA	β , free stream angle of sideslip seen by source panels, degrees ($=\sin^{-1}(\sin(\text{ALPHAC}) \cdot \sin(\text{PHIR}))$)
ALPHAC	α_c , included angle of attack seen by source panels, degrees
PHIR	ϕ_r , angle of roll seen by source panels
EM	temporary Mach number of last computation
SINAC	$\sin(\alpha_c)$
COSAC	$\cos(\alpha_c)$
SPHI	$\sin(\phi_r)$
CPHI	$\cos(\phi_r)$

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PREDICTION OF SUPERSONIC STORE SEPARATION CHARACTERISTICS INCLU--ETC(U)
NOV 80 J MULLEN, F K GOODWIN, M F DILLENIUS F33615-76-C-3077
NEAR-TR-210-VOL-3 AFWAL-TR-80-3032-VOL-3 NL

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DATE
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SINA $\sin(\alpha)$

SINB $\sin(\beta)$

COMMON /PYGEOM/ Z(20),XPLE,YPL,CRP,HP,PSIPLE(20),PSIPTE(20),IP,
 SLLE,PSLPOF,CENTER,ZPL,LVSPP

Z(K) z_p locations of pylon u-velocity panel side edges;
 input item 45

XPLE location of pylon root chord leading edge; input
 item 43

YPL y_w location of the pylon; YPL=Y(IP) of input
 item 37

CRP pylon root chord; input item 43

HP pylon height; input item 43

PSIPLE(K) leading-edge sweeps of pylon u-velocity panels;
 input item 45

PHIPTE(K) trailing-edge sweeps of pylon u-velocity panels;
 input item 45

IP index of y_w location of the pylon; input item 43

SLLE slope of pylon leading edge for Ith chordwise row
 of pylon panels

PSLPDF difference in leading and trailing edge slopes
 PSLPDF = SLLE-SLTE for Ith chordwise row of
 pylon panels

CENTER logical test for centerline pylon (CENTER=YPL.EQ.0)

ZPL z_w location of the pylon; ZPL=ZLC((IP-2)•NCW+1)

LVSPP breaks in pylon sweep indicator, LVSPP=0, no;
 LVSPP=1, yes

COMMON /RKGEOM/ RRMAX,RLTHC,XWROC,YWRO,ZERO,NRPOLY,RXEND(7),
 RCOEF(7,7),XBRO,YBRO,ZBRO,RIBCR,SRIBCR,CRIBCR

RRMAX maximum rack radius; input item 49

RLTHC length of rack; input item 49

XWROC	x_w location of rack in wing coordinates, feet
YWRO	y_w location of rack in wing coordinates, feet
ZWRO	z_w location of rack in wing coordinates, feet
NRPOLY	number of rack shape polynomials; input item 50
RXEND(J)	rack polynomial endpoints; input item 51
RCOEF(I,J)	rack polynomial coefficients; input item 52
XBRO	x_B location of rack in body coordinates, feet
YBRO	y_B location of rack in body coordinates, feet
ZBRO	z_B location of rack in body coordinates, feet
RIBCR	RIC•DTOR; input item 49 for RIC
SRIBCR	sin(RIBCR)
CRIBCR	cos(RIBCR)
COMMON /RSHOCK/ NRSHK,RXSHK(50),RRSHK(50),RDRDX(101)	
NRSHK	number of x and r values in rack nose shock table generated from line singularities
RXSHK(I), RRSHK(I)	x and r coordinates of Ith rack nose shock location at zero angle of attack, feet
RDRDX(J)	DR/DX at Jth rack control point
COMMON /RSOR/ RXL(101),RSS(101),RDS(101),NRSOR	
RXL	array containing the x positions of the rack sources; positive, measured from tip of rack nose
RSS	array containing the strengths of the rack source distribution
RDS	array containing the strengths of the rack doublet distribution
NRSOR	number of rack sources and doublets; input item 53

COMMON /SHPDAT/ NFPOLY,FXEND(7),FCOEF(7,7)

NFPOLY number of fuselage polynomials; input item 6

FXEND x/l of fuselage polynomial endpoints; input
 item 7

FCOEF coefficients of fuselage polynomials; input
 item 8

COMMON /SSHOCK/ NSSHK(7),SXSHK(50,7),SRSHK(50,7),SDRDX(101,7)

NSSHK(J) number of x and r values in Jth store nose shock
 table generated from line singularities

SXSHK(I,J), x and r coordinates of Ith circular store shock
SRSHK(I,J) location at zero angle of attack for Jth store

SDRDX(K,J) DR/DX at Kth circular store control point of Jth
 store

COMMON /SSOR/ SXL(101,7),SSS(100,7),SDS(100,7),NSSOR(7)

SXL(I,J) Ith x-position of Jth circular store sources;
 positive measured from tip of nose

SSS(I,J) Ith source strength of distribution for Jth
 circular store

SDS(I,J) Ith doublet strength of distribution for Jth
 circular store

NSSOR(J) number of Jth circular store sources and doublets;
 equal to input item 56

COMMON /STGEOM/ SRMAX(7),SLTHC(7),XWSOC(7),YWSO(7),ZWSO(7),
 NSPOLY(7),SXEND(7,7),SCOEF(7,7,7),XBSO(7),YBSO(7),
 ZBSO(7),SIBCR(7),NUMSTR(7),SSIBCR(7),CSIBCR(7),
 SPHIRR(7),NSHAPE(7),NSHPT,MSHAPE(7)

SRMAX(J) maximum radius of Jth store; input item 54

SLTHC(J) length of Jth store; input item 54

XWSOC(J) x_w coordinate of tip of nose of Jth store

YWSO(J) y_w coordinate of tip of nose of Jth store

ZWSO(J)	z_w coordinate of tip of nose of Jth store
NSPOLY(J)	number of polynomials used to specify the shape of the Jth store
SXEND(I,J)	endpoints of polynomial sections specifying shape of Jth store
SCOEF(I,K,J)	Jth coefficient of Ith polynomial describing the shape of the Jth store
XBSO(J)	x_B coordinate of tip of nose of Jth store
YBSO(J)	y_B coordinate of centerline of Jth store
ZBSO(J)	z_B coordinate of tip of nose of Jth store
SIBCR(J)	$SIC(J)*DTOR$; input item 54 for $SIC(J)$
NUMSTR(J)	store number; input item 54
SSIBCR(J)	$\sin(SIBCR(J))$
CSIBCR(J)	$\cos(SIBCR(J))$
SPHIRR(J)	initial roll angle of Jth store coordinate axes; positive right wing down, radians
NSHAPE(J)	store shape number, input item 54
NSHPT	number of different store shapes; input item 55
MSHAPE(K)	shape number of Kth store shape; input item 56
COMMON /SRCE/ XFIELD,RFIELD,BSQ,X2,U,V,VT	
XFIELD	center of line source/doublet segment, feet
RFIELD	circular body radius at XFIELD, feet
BSQ	not used
X2	not used
U	axial velocity due to a source
V	radial velocity due to a source
VT	not used

COMMON /THKDAT/ NCWS,NCPS,MS,MPS,MSWS,MSPS,NTHP,XRFT(400),XRBT(400),
 XLFT(400),XLBT(400),YRCT(400),YLCT(400),ZRCT(400),ZLCT(400),
 THETAL(400),THETPL(200),SLEET(400),SLTET(400),DZDX(400),
 YS(20),PSWSLE(20),PSWSTE(20),PHIS(20),ZS(20),PSPSLE(20),
 PSPSTE(20),SNPHS(400),CSPHS(400)

NCWS	number of wing thickness panels in a chordwise row; input item 40
NCPS	number of pylon thickness panels in a chordwise row; input item 46
MS	number of thickness panels on wing
MPS	number of thickness panels on pylon
MSWS	number of wing thickness panels in a spanwise row; input item 40
MSPS	number of pylon thickness panels in a spanwise row; input item 46
NTHP	number of thickness panels on wing and pylon
XRFT(I)	x_w coordinate of right front corner of Ith thickness panel
XRBT(I)	x_w coordinate of right rear corner of Ith thickness panel
XLFT(I)	x_w coordinate of left front corner of Ith thickness panel
XLBT(I)	x_w coordinate of left rear corner of Ith thickness panel
YRCT(I)	y_w coordinate of right side of Ith thickness panel
YLCT(I)	y_w coordinate of left side of Ith thickness panel
ZRCT(I)	z_w coordinate of right side of Ith thickness panel
ZLCT(I)	z_w coordinate of left side of Ith thickness panel
THETAL(I)	wing thickness slopes; input item 42
THETPL(I)	pylon thickness slopes; input item 48
SLEET(I)	slope of leading edge of Ith thickness panel
SLTET(I)	slope of trailing edge of Ith thickness panel

DZDX(I) dz/dx of Ith thickness panel
 YS(J) y_w locations of wing thickness panel side edges;
 input item 41
 PSWSLE(J) leading-edge sweeps of wing thickness panels;
 input item 41
 PSWSTE(J) trailing-edge sweeps of wing thickness panels;
 input item 41
 PHIS(J) wing thickness panel dihedrals; input item 41
 ZS(J) z_p locations of pylon thickness panel edges;
 input item 47
 PSPSLE(J) leading-edge sweeps of pylon thickness panels;
 input item 47
 PSPSTE(J) trailing-edge sweeps of pylon thickness panels;
 input item 47
 SNPHS(J) sin(PHIS(J))
 CSPHS(J) cos(PHIS(J))

COMMON /THVARG/ X,YV,ZV,U,VV,WV,EML,PRT*

X,YV,ZV x,y,z coordinates of field point in thickness
 panel coordinate system
 U,VV,WV u,v,w velocity components in thickness panel
 coordinate system
 EML slope of thickness panel leading or trailing edge
 PRT not used

COMMON /VELARG/ X,YV,ZV,U,VV,WV,EM,TLRNC,TIPY,PYPNL*

X,YV,ZV x,y,z coordinates of field point in u-velocity
 panel coordinate system
 U,VV,WV u,v,w velocity components in u-velocity panel
 coordinate system

* Variable names may differ from routine to routine but the definitions are unchanged.

EM slope of u-velocity panel leading or trailing edge
 TLRNC error tolerance
 TIPY exposed wing span
 PYPNL logical pylon indicator

COMMON /WGEOM/ XBWOC,ZBWO,CRW,SLPWLE,SLPWTE,PSIWLE(20),
 PSIWTE(20),Y(20),PHID(20),ZDIHED,WICR

XBWOC x_B coordinate of wing root chord leading edge;
 input item 34
 ZBWO z_B coordinate of wing root chord leading edge;
 input item 34
 CRW wing root chord; input item 35
 SLPWLE $\tan(\text{PSIWLE}(I))$
 SLPWTE $\tan(\text{PSIWTE}(I))$
 PSIWLE(I) leading-edge sweeps of wing u-velocity panels;
 input item 37
 PSIWTE(I) trailing-edge sweeps of wing u-velocity panels;
 input item 37
 Y(I) y_w locations of wing u-velocity panel side edges;
 input item 37
 PHID(I) dihedral angles of wing u-velocity panel sections;
 input item 37
 ZDIHED logical variable indicating whether or not there
 is wing dihedral; ZDIHED=TRUE, no dihedral;
 =FALSE, there is dihedral
 WICR wing incidence angle, radians; computed from WIC,
 input item 34

COMMON /WPGEOM/ XRF(200),XRB(200),XLF(200),XLB(200),YRC(200),
 YLC(200),SCPT(200),YCPT(200),ZCPT(200),SWPPLE(200),
 SWPTE(200),SNPHI(200),CSPHI(200)

XRF(I) x_w coordinate of right rear corner of Ith constant
 u-velocity panel
 XRB(I) x_w coordinate of left front corner of Ith constant
 u-velocity panel

XLF(I)	x_w coordinate of left rear corner of Ith constant u-velocity panel
XLB(I)	x_w coordinate of right front corner of Ith constant u-velocity panel
YRC(I)	y_w coordinate of left edge of Ith constant u-velocity panel
YLC(I)	y_w coordinate of right edge of Ith constant u-velocity panel
XCPT(I)	x_w coordinate of Ith control point
YCPT(I)	y_w coordinate of Ith control point
ZCPT(I)	z_w coordinate of Ith control point
SWPPLE(I)	sweep of leading edge of Ith constant u-velocity panel on wing, fuselage or pylon
SWPPTE(I)	sweep of trailing edge of Ith constant u-velocity panel on wing, fuselage or pylon
SNPHI(I)	sine of dihedral angle of Ith constant u-velocity panel on wing
CSPHI(I)	cosine of dihedral angle of Ith constant u-velocity panel on wing
COMMON /XSHOLD/ FXSHLD,RXSHLD,SXSHLD(7)	
FXSHLD	x_B location of circular fuselage shoulder, feet
RXSHLD	x_R location of rack shoulder, feet
SXSHLD(J)	x_S location of Jth circular store shoulder, feet

B-3 Blank Common

The requirement for handling the many large arrays associated with the solution for u-velocity and source panel strengths has necessitated both the use of out of core data handling and storage and the setting aside of a scratch storage area in core to be used for more than one purpose. To handle the latter data requirement blank common has been reserved for all calculations involving large arrays. The program flow of calculations is thus arranged to allow variables to be read from or written to external files as needed. The following describes the Program I sequence of references to external files and which arrays reside in blank common at each point in the program flow. The information residing in each of the external files is described later.

In Program I blank common is used for three purposes: (1) storing the dynamically dimensioned arrays associated with both the noncircular fuselage and the elliptic store; (2) storing the wing-fuselage u-velocity aerodynamic influence coefficients during the solution for panel strengths; and (3) temporary storage of arrays associated with the summation of u-velocity singularity strengths at panel corners. The descriptions which follow focus on the definition of quantities during these phases. The non-circular fuselage and elliptic store arrays are lumped together because they share common code. Only the dimensions of arrays will vary between components. The arrangement of variables in blank common during these calculations may change dynamically as the solution progresses as temporary arrays are required or discarded. The flow chart in Figure A-2 of Appendix A also identifies several points in the program, item numbers, where external files are referenced. The comments which follow are keyed to the usage of blank common at those points wherever possible. The descriptions of the use of blank common during these three phases follow.

The first use of blank common is to store the arrays of panel properties and solutions of either the noncircular fuselage or the

elliptic store. This spans items 1 through 4 for the fuselage and repeats as item 5 for the store in Figure A-2. The first routine using blank common is GEOM as called from WDYBDY. The noncircular and elliptic store both share the same analysis routines and blank common data arrays. In Program I, the results of the first are computed and all information required for Program II are saved. The solution for a single body is broken into four parts. These follow the progress of calculations and correspond to generation of panel geometry, computation of panel aerodynamic influence coefficients, solution of the equations, and saving of appropriate arrays required for Program II. Because of the large number of possible combinations of paneling schemes, all array storage allocation in blank common is performed dynamically. That is, the array length is computed and core locations set aside prior to calculation of the array itself. Arrays are typically stacked one behind another with no unused locations in between. No explicit array names or dimensions are defined in blank common. Only the address in blank common of the first element in the array is saved in labeled common, DIMENS.

The first use of blank common within the calculation of the source panel geometry (item 1) is for temporary storage of the arbitrary Y,Z input of the external fuselage shape as read directly from input cards. They are followed by the intermediate YB and ZB values computed at axial stations, XFUS, at the new meridional angles, PHIK, of the revised panel spacing layout. Blank common is equivalently dimensioned to:

```
COMMON  SFUS(NRAD,2,NFUSOR),YB(NFUSOR,KRAD),ZB(NFUSOR,KRAD),...
        A(NADIM)
```

where

```
SFUS(NN,1,N)  y-station in local body coordinates of the
               NNth meridian at the Nth axial station,
               XFUS

SFUS(NN,2,N)  z-station in local body coordinates of the
               NNth meridian at the Nth axial station,
               XFUS
```

YB(N,K)	y-station in local body coordinates of the Nth axial station for the Kth revised meridional angle
ZB(N,K)	z-station in local body coordinates of the Nth axial station for the Kth revised meridional angle

If more than one segment exists YB and ZB are saved on TAPE8 for each of NFUS segments.

The second change in the use of blank common as identified by item 2 in Figure A-3 is to store the arrays containing the geometric properties of the source panels. The configuration of blank common at this point in the calculations remains the same while continuing to grow. Arrays which are to be saved are located at the beginning with scratch space at the rear. From the end of the calculations in GEOM, the arrays in blank common contain all the panel geometric properties required for calculation of influence coefficients and the resolution of forces and moments. Additional temporary arrays are allocated to hold the ring-by-ring coefficient arrays in VELCMP. The equivalently dimensioned arrays in blank common look like:

```
COMMON  XPT(NBODY),YPT(NBODY),ZPT(NBODY),THET(NBODY),
        DELTA(NBODY),AREA(NBODY),XC(KX),YC(KXKR),
        ZC(KXKR),AN(MAXKR,MAXKR),UB(3,MAXKR,MAXKR),...,
        A(NADIM)
```

where

XPT(I)	x-station of control point of Ith panel
YPT(I)	y-station of control point of Ith panel
ZPT(I)	z-station of control point of Ith panel
THET(I)	inclination angle at Ith panel control point
DELTA(I)	incidence angle of Ith panel
AREA(I)	surface area of Ith panel
XC(L,M)	panel corner points at Lth axial station of Mth segment

YC(L,N,M)	y corner point at Lth axial station of Nth meridional angle of Mth segment
ZC(L,N,M)	z corner point at Lth axial station of Nth meridional angle of Mth segment
AN(I,J)	temporary array for aerodynamic influence coefficients
UB(1,I,J)	temporary u-component influence coefficient array
UB(2,I,J)	temporary v-component influence coefficient array
UB(3,I,J)	temporary w-component influence coefficient array

The dimensions and indices defining the starting locations of each of these equivalent arrays are found in common DIMENS. The starting indices may typically be found by preceding the first two or three letters of the array name with I.

Additional arrays associated with the solution for the panel source strengths in SOLVE as identified by item 3 in Figure A-2. Only the arrays containing the panel strengths are saved. The strengths for up to seven flow conditions may be retained to allow for using the same shape data for more than one store. The equivalently dimensioned arrays in blank common looks like:

```
COMMON  XPT(NBODY),YPT(NBODY),ZPT(NBODY),THET(NBODY),
        DELTA(NBODY),AREA(NBODY),XC(KX),YC(KXKR),ZC(KXKR),
        GB(NBODY,IALP),VB(NBODY),AN(MAXKR,MAXKR),...,
        A(NADIM)
```

where the arrays XPT through ZC contain the same information as before and

GB(I,J)	strength of Ith panel for fuselage (J=1) or Jth store of given shape
VB(I)	temporary array; contains initial velocity boundary condition which is destroyed during the solution

AN(I,J) temporary array; used to hold the aerodynamic
 influence coefficients

At the conclusion of the calculation of the fuselage body source strengths identified by a call to IOWRIT in Figure A-2, arrays XPT through GB are saved on TAPE7. At the conclusion of the remaining body calculations all arrays required for Program II are saved on TAPE10. This occurs during the call to routine FRSTRT identified as item 4 in Figure A-2. For the fuselage, all variables and arrays in common blocks BGEOM, BOPTNS, BINLET, BINSHK, BSHOCK, DIMENS, HEAD, PARAM, and the blank common arrays previously saved on TAPE7 are written onto TAPE10. These commons contain all the information necessary to restart the calculations in Program II.

In Program I when both a noncircular fuselage and an elliptic store are to be analyzed, the results of the fuselage calculation are saved on an external file as indicated above. The data for the store or stores overwrite previous values. The sequence employed in computing elliptic store panel strengths is performed in a slightly different manner from the fuselage. In order to take maximum advantage of similarities in store shapes, the geometric properties of the panels and aerodynamic influence coefficients of a given shape are computed only once. The placement of a store in a different position or orientation causes only a variation in the boundary conditions. Only the strengths of the source panels associated with the additional stores of identical shape have to be saved. Provision for two elliptic store shapes is included in the program.

The computation sequence for the stores has been modified to read the geometric store input by shape first. The aerodynamic influence calculations are then made for each individual store. The impact of this sequence of computations for the store in blank common is to break the sequence 1 through 4 as used for the fuselage after item 2 in order to temporarily save all arrays

on TAPE11. This break in the sequence is indicated by item 5 in Figure A-2. At this point arrays XPT through ZC and common blocks BGEOM, BOPTNS, BSHOCK, DIMENS, HEAD, and PARAM are saved for each of the elliptic store shapes as previously described for the fuselage. The loop on the number of shapes is then repeated in which the above variables are read and the source strengths computed for each of the stores of that shape. The above labeled common blocks and arrays XPT through GB are saved on TAPE10 by routine FRSTRT. Blank common is then used to copy the aerodynamic influence coefficients from TAPE9 and TAPE8 to TAPE10. Blank common is equivalently dimensioned as

```
COMMON  AN(KRAD,KRAD),...,A(NADIM)
```

for the TAPE9 transfer and then

```
COMMON  UB(3,KRAD,KRAD),...,A(NADIM)
```

for the TAPE8 transfer of data.

TAPE10 is rewound and the records containing the fuselage arrays are read for use by DPHRS at item 6 in Figure A-2. FRSTRT reinitializes blank common and the various labeled commons identical to that configuration at the point identified by item 3 to allow use of the noncircular fuselage solution for the wing boundary conditions.

The second use of blank common in Program I is to contain the aerodynamic influence coefficients associated with the u-velocity panel solution for the wing-fuselage-pylon of the parent aircraft. At item 7 in Figure A-2 DPCOEF uses blank common to hold the coefficients and the right hand side through the panel strength solution. For these computations blank common has the dimensions of

```
COMMON  FVN(200,N+1)
```

where

FVN(I,J) u-velocity panel influence coefficients

FVN(I,N+1) on input is the boundary condition of the Ith
 panel; on output is the strength of the Ith
 panel

N number of u-velocity panels

The third use of blank common in Program I is to contain the arrays used in the condensation of u-velocity panel strengths to strengths associated with single corners. Blank common is used to contain the arrays of corner points, net strengths, and orientation information. These calculations are performed in routine NULYT identified as item 8 in Figure A-2. The information is retained in blank common only until it can be written onto TAPE12 by WRFILE. During this time blank common has the dimensions of

COMMON XPT(500),YPT(100),ZPT(100),SPHI(40),CPHI(40),
 SWP(500),SNBP(40),CSBP(40),THTBP(40),DPNET(500),
 XPTS(1000),YPTS(100),ZPTS(100),SPHS(40),CPHS(40),
 SWPS(1000),THTNET(1000)

where

XPT(I) x_w coordinate of Ith wing/body/pylon constant
 u-velocity corner point

YPT(J) y_w coordinate of Jth chordwise row associated
 with wing/body/pylon constant u-velocity
 corner points

ZPT(J) z_w coordinate of Jth chordwise row associated
 with wing/body/pylon constant u-velocity
 corner points

SPHI(J) sine of dihedral angle associated with Jth row
 of wing constant u-velocity corner points

CPHI(J) cosine of dihedral angle associated with Jth
 row of wing constant u-velocity corner points

SWP(J) leading-edge slope of semi-infinite influencing
 triangle associated with Jth constant u-velocity
 corner point

SNBP(J)	sine of orientation angle of Jth row of body interference shell u-velocity corner points
CSBP(J)	cosine of orientation angle of Jth row of body interference shell u-velocity corner points
THTBP(J)	polar angle in cross-sectional plane defining the Ith row of fuselage constant u-velocity corner points; positive in counterclockwise rotation from positive y_B axis
DPNET(I)	net strength of Ith constant u-velocity corner point
XPTS(I)	x_w coordinate of Ith wing/pylon thickness source panel corner point
YPTS(J)	y_w coordinate of Jth chordwise row of wing/pylon thickness source panel corner points
ZPTS(J)	z_w coordinate of Jth chordwise row of wing/pylon thickness source panel corner points
SPHS(J)	sine of dihedral angle associated with Jth row of wing source panel corner points
CPHS(J)	cosine of dihedral angle associated with Jth row of wing source panel corner points
SWPS(I)	leading-edge slope of semi-infinite influencing triangle associated with Ith source panel corner point
THTNET(I)	net strength of Ith thickness source panel corner point

Blank common is last used in Program I by FRSTRT as previously mentioned as temporary array space to copy the source panel data for the fuselage and store bodies from TAPE10 to TAPE12. See descriptions of FRSTRT for sequence of operations involved in file transfer. This reference to blank common is identified as item 9 in Figure A-2.

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